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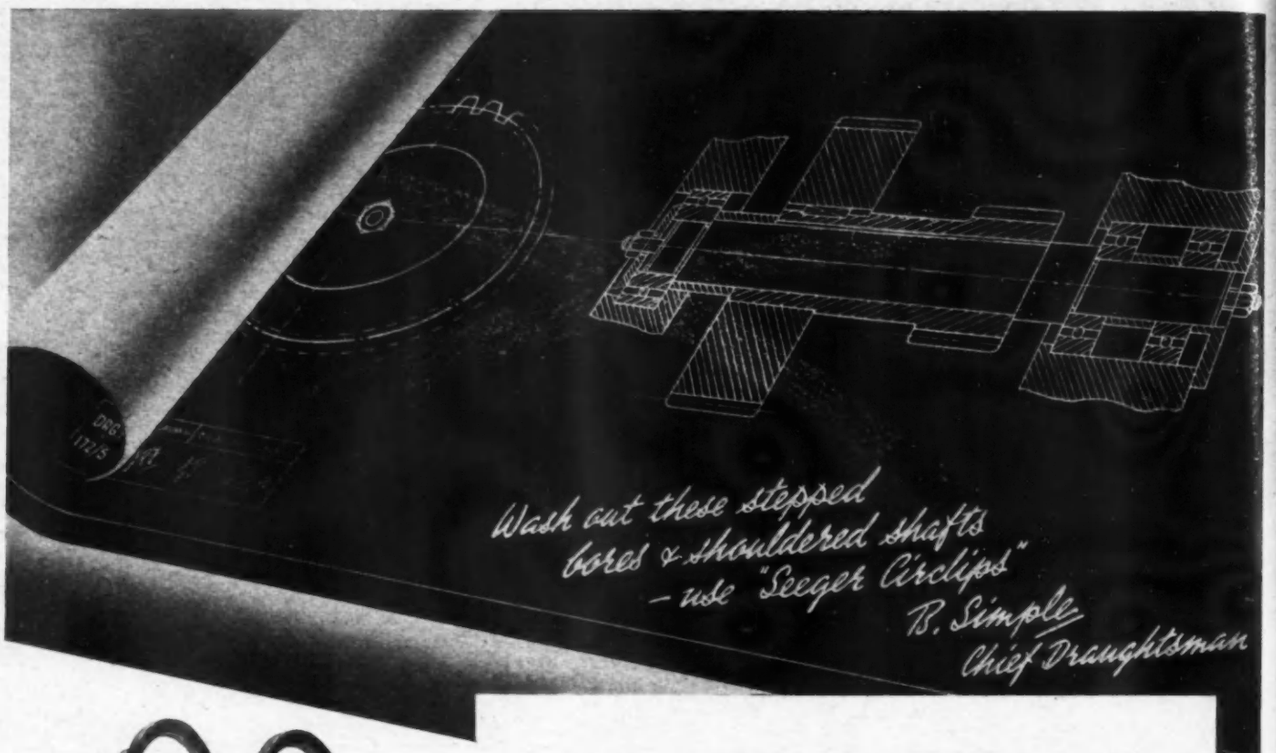

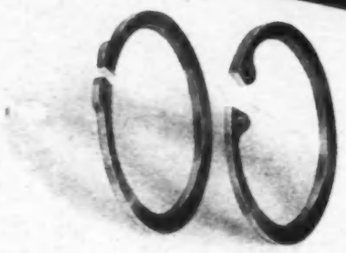

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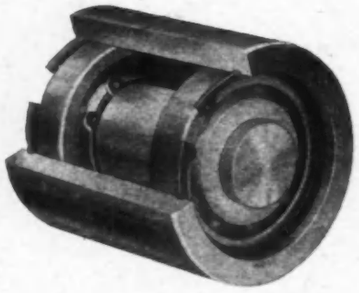

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THE CONTROL OF POWER IN LARGE INTER-CONNECTED ELECTRIC SUPPLY SYSTEMS.

By T. F. WALL, D.Sc.

(*Continued from page* 4.)

SURGE EFFECTS.

§10. *Impulse Voltage.*—The problem of protecting electrical installations from the dangers of pressure rises due to atmospheric electrical disturbances dates from the beginning of the electric supply industry, but the various types of protective devices, such as horn-arresters, choke coils, capacitances and allied appliances, have never produced any feeling of confidence among the responsible engineers of supply undertakings as regards their efficacy and reliability. The introduction of the Petersen coil greatly reduced the number of electric supply disturbances due to atmospheric electric storms, but it was not until 1925 that accurate graphic representation of such surge phenomena was obtained. In that year Rogowski was able to obtain, for the first time, by means of the cathode-ray oscillograph,

Fig. 12.

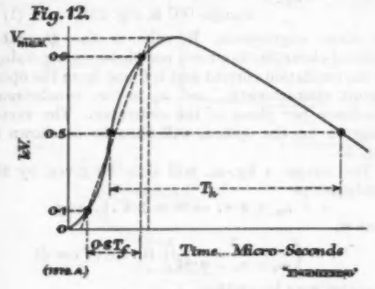
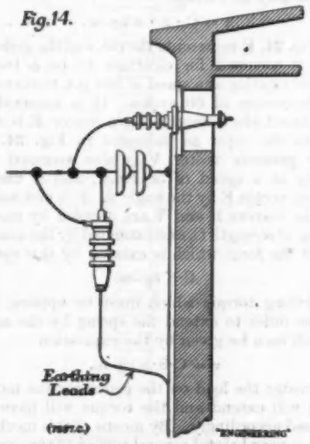


Fig. 14.



photographs of travelling surges of pressure on transmission lines. The duration was of the order of a few millionths of a second.

The characteristics of a travelling surge of pressure or "impulse voltage"* may be defined with reference to Fig. 12, on this page :—

(*a*) An "impulse voltage" is a single uni-directional voltage, which, without appreciable oscillations, rises rapidly to a maximum value and declines more or less rapidly to zero. The maximum value is called the crest value of the impulse and the impulse voltage is specified by this value.

(*b*) The "wave-front" of an impulse voltage is the rising portion of the time-voltage characteristic.

(*c*) The "wave-tail" of an impulse voltage is the falling portion of the time-voltage characteristic.

(*d*) The "duration of the wave-front" is the total time occupied by the impulse voltage in rising from zero to the crest value. For the sake of convenience, a nominal value T_f of the duration, in micro-seconds, of the wave-front is defined by :—

1·25 × the time interval between points on the wave-front where the voltage is 10 per cent. and 90 per cent. of the crest value.

(*e*) The "time to half-value of the wave-tail" of an impulse is the total time occupied by the impulse voltage in rising to crest value and declining therefrom to half the crest value.

(*f*) The "nominal steepness of the wave-front" of an impulse is the rate of rise of voltage measured between the points of the wave-front where the voltage is 10 per cent. and 90 per cent. of the crest value, respectively, and is expressed in kilovolts per micro-second.

§11. *The Problem of Surge Protection.*—Although the nature of the problem of protection against surge pressures had been previously well known, and studied in considerable detail, it was only when the cathode-ray oscillograph became sufficiently developed that the possibility was realised of obtaining exact experimental data of the physical phenomena associated with atmospheric electrical surges. Immediately this became possible, intensive research, in many countries of the world, was concentrated on these problems and has resulted in the accumulation of such a store of exact experimental knowledge that it may now be said that danger of disturbances of electric supply systems due to

Fig. 13.

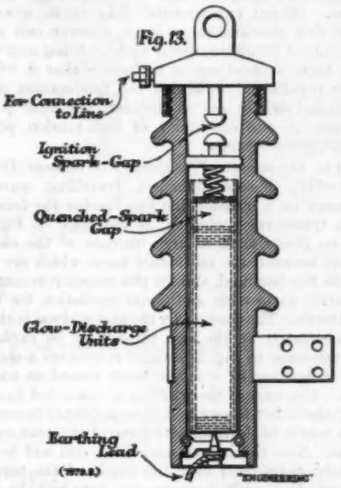
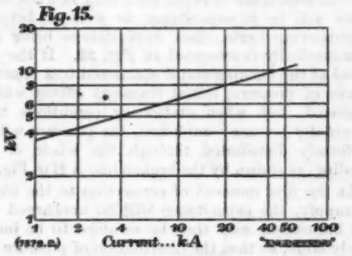


Fig. 15.



thunder storms and atmospheric electrical storms is within sight of being completely eliminated, even under the most drastic conditions which can be experienced in practice, viz., a direct lightning stroke into the line itself.

The essential features of a surge arrester are :—

(i) The internal resistance must automatically adjust itself to the magnitude of the current which has to be dealt with, so that the product of current and resistance shall be such that the pressure drop will remain approximately constant and tend towards some limiting value which will be less than the breakdown strength of the insulation of the system.

(ii) When the pressure rises to the response value of the arrester, the path for the passage to earth of the dangerously high portion of the surge-profile (that is, the "over-voltage"), must open without any time-lag.

(iii) The current flow in the arrester immediately after the discharge must, as far as possible, produce no detrimental effect on the arrester.

(iv) After the passage of the high-pressure surge, the current which would flow due to the normal supply voltage of the system must be completely and instantaneously interrupted, so that no harm may be caused to the installation.

§12. *The Glow-Discharge Arrester.*—This appliance is based on an idea which was originally advanced by J. Slepian and which may be briefly outlined as follows : If the gap between two disc electrodes across which a p.d. exists is reduced from, say, a few millimetres, the breakdown voltage at atmospheric pressure of the air-space between them will also be reduced until a minimum value of about 350 volts is reached. If the gap is still further reduced, the breakdown voltage will rise. If the discharge between the two electrodes when at this critical distance is stabilised (see below), it will be found that a p.d. of about 300 volts is necessary to maintain the glow-discharge. When the striking pressure is 350 volts, the pressure will fall to 300 volts when the glow-discharge is established, and when the pressure falls below this value the discharge will cease.

In order to stabilise the glow-discharge, Slepian used electrodes of resistance material (*e.g.*, carborundum), in consequence of which it became impossible for the discharge current to concentrate

Fig. 16.

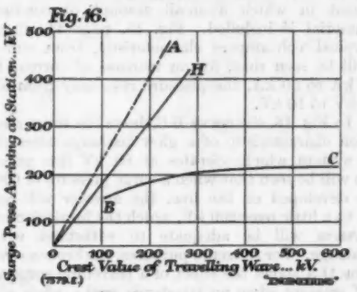
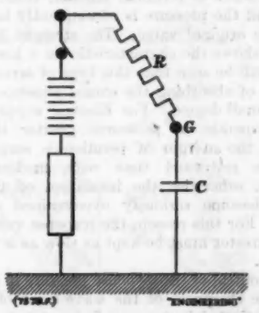


Fig. 17.



at individual points on the surface of the electrode. For this reason, the glow-discharge could not develop into an arc (see also §§6 and 8, pages 2 and 3, *ante*). The discharge between the disc electrodes can be seen in the dark as a clear blue and reddish glow, and it is possible to discern the increase of the surface area which is covered by the glow as the current strength increases, in accordance with what has been said already in §6, relative to this characteristic phenomenon of this type of electric discharge.

The possibilities of the practical application of Slepian's idea for use on high-tension power transmission systems was fully investigated by several independent specialists who all came to the conclusion that this was not feasible, one reason being that the response voltage was higher for travelling pressure waves than for a static discharge, or for a discharge due to a low frequency supply and that this discrepancy between the two conditions depended upon the steepness of the wave front. For example, for a wave front of 20 m., the response pressure is about 1,000 volts, instead of 350 volts for low frequency alternating current ; for a wave front of 800 m., the response pressure is about 850 volts. A further disadvantageous feature of Slepian's original device was that it possessed a definite time-lag, the amount of this depending on the time required for a positive ion to travel from the anode to the cathode. During the last few years, these objectional features have been eliminated and the operation of the glow-discharge arrester has been improved to such an extent that

* See I. E. C., *General Specifications for Impulse-Voltage Tests*, Publication No. 60.

it may be said to be practically ideal for its purpose. While, in the original form, the adjacent disc electrodes were separated by a mica spacing ring of 0·1 mm. thickness, in the modern form no such spacing ring is used. The electrodes are formed with an extremely thin skin, so that they only touch at individual points, due to the natural unevenness of the disc surfaces, the mean distance of separation being about 0·02 mm. In order definitely to interrupt the current which would flow across these points of contact, a "quenched spark" type of gap is inserted in series and, in addition, a spherical spark-gap is included in the circuit, the whole arrangement being such that the response voltage of the arrester is about twice the normal operating voltage of the system. Fig. 13, on page 41, shows a cross-sectional view of such an arrester constructed for a line pressure of 15 kV, and Fig. 14 shows the method of installing the arrester for the protection of a terminal station. Great improvements have also been made in the nature of the resistance material which is used for the disc electrodes, this material now being prepared from a mixture of semi-conducting crystals with a binding agent in which a small amount of conducting material is included. Fig. 15, page 41, shows a typical volt-ampere characteristic, from which it will be seen that, for an increase of current from 1 kA to 50 kA, the pressure rises only from about 4 kV to 10 kV.

In Fig. 16, the curve B C shows the surge absorption characteristic of a glow-discharge arrester for a system which operates at 60 kV line pressure. It will be seen that when a surge pressure of 600 kV is developed on the line, the arrester will reduce it to a little over 200 kV, which the insulation of the system will be adequate to withstand without damage. For reference purposes, the broken straight line O A shows the effect of a travelling surge wave of pressure when no arrester is used; when such a surge reaches a terminal station, reflection takes place and the pressure is consequently increased to twice its original value. The straight line O H in Fig. 16 shows the characteristic for a horn-arrester, and it will be seen that this type of arrester is only capable of absorbing the excess pressure to a relatively small degree. For Electric supply systems which operate at pressures greater than about 80 kV, the margin of permissible surge pressure is more restricted than with medium tension systems, otherwise the insulation of the system would become seriously overstrained and break down. For this reason, the response voltage of the surge arrester must be kept as alow as is reasonably possible.

The control of the response pressure in accordance with the steepness of the wave-front of the surge can be effected by means of a guard ring. In this way the pressure distribution in the spherical spark-gap becomes automatically adjusted according to the steepness of the wave-front. The principle of operation will be understood by reference to Fig. 17, on page 41. The guard ring G is connected to the line through a high resistance R, this resistance being contained in the spokes of the guard-ring. The capacity to earth of the ring is C farad, so that the current which will flow in the series circuit of R and C will be

$$I = \frac{V}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$$

For currents at the line frequency of 50, the capacitance reactance will be about $\frac{1}{\omega C} = 10^6$ ohms, and the resistance in series will be $R = 10^6$ ohms; that is to say, the resistance will be small relatively to the capacitance reactance and in consequence the guard-ring potential will be brought not far below the line pressure. When, however, a travelling surge appears on the line, the effective value of the circular frequency will be immensely increased, so that, for example, while the resistance R remains the same, viz., $R = 10^6$ ohms, the capacitance reactance becomes $\frac{1}{\omega C} = 10^4$. In this case, therefore, the resistance is large as compared with the capacitance reactance and, in consequence, the potential of the guard ring is lowered towards the earth potential.

The effect of this change of frequency from the low frequency value of the supply to the very high frequency of the surge wave-front is shown in Fig. 18, opposite. On the right-hand portion of this diagram the potential distribution is shown for the case in which the current is the low frequency of the supply, viz., 50, and it will be seen that only a small proportion of the total p.d. is concentrated across the spherical gap; the response pressure of the arrester will be correspondingly large. On the left-hand portion of this diagram, the p.d. concentrated across the spherical gap is relatively large and, in consequence, the response pressure of the arrester is correspondingly small. Fig. 19 shows the complete arrester unit with guard-ring as constructed for a system of 132 kV line pressure.

In the earlier stages of the development of this type of surge arrester, it was not contemplated that it could deal successfully with a direct lightning stroke into the line, since this would involve current strengths of very high values; the channel of a lightning stroke would frequently carry currents as high as 60,000 amperes, while in some cases this current would reach values of 200,000 amperes and more. Recent experimental data show, however, that this glow-discharge surge arrester can carry currents of 300,000 amperes without being destroyed and there is good reason to believe that it will be fully capable of protecting the line against direct lightning strokes and so eliminate the most potent menace to the continuity of high-tension power-transmission systems.

§13. *Stresses in Transformer Windings Due to Travelling Waves.*—When a travelling wave of pressure on a transmission line reaches the terminal of a transformer winding, as indicated in Fig. 20, it can give rise to a large increase of the electric stress between the individual turns which are near to the line terminal, and for this reason it is common practice to provide additional insulation for these end turns. The reason why the excess stress is chiefly concentrated at the end turns may be explained by reference to Fig. 21, which represents a choking coil consisting of a single layer wound on an iron core. One end of the winding is connected to earth and the other is assumed to be suddenly connected to a source of electromotive-force of constant magnitude. Now the inductance of the coil will be uniformly distributed over the whole of the turns of the winding, while between each turn and the earth there will be a capacitance as well as between neighbouring turns, these capacitances being diagrammatically represented in Fig. 21. If the terminal of the choking coil is connected to a constant source of pressure, initial transient effects will be produced, but when stationary conditions have eventually become established, the pressure will be uniformly distributed through the whole of the winding, as shown by the broken line A B in Fig. 22.

At the first moment of connection to the source of supply, the capacitance will be uncharged and the inductance may then be assumed to be indefinitely large, so that the distribution of pressure will be solely determined by the system of capacitances as is shown by the curve A C B in Fig. 22, the conditions being similar to those which exist in the case of a chain of line insulators. It is seen, therefore, that the turns near the line terminal of the transformer winding will have to stand a much larger proportion of the total pressure than the turns near the earth terminal. After a very short time interval has elapsed, this initial and transient distribution of pressure will have settled down to the stationary condition represented by the broken straight line A B. The change from the initial conditions to the final steady conditions of stress will be effected by means of a series of damped oscillations comprising a large range of oscillation frequencies and during this transition the superposition of this series of transient pressure waves may result in extremely large momentary stresses, so that the insulation will break down. The characteristics of these oscillatory effects cannot be calculated with any great accuracy, and the design and construction of the reinforced insulation of the end turns can only be based on the results of long experience and will consequently be subject to considerable uncertainty in individual cases.

Means have recently been devised which will practically eliminate the development of excess stresses due to unequal distribution of pressure when a travelling surge reaches the terminal of a transformer winding. The principle of the method is so to design the winding that the pressure distribution due to the capacitance system shall be in accordance with the broken straight line A B, in Fig. 22, the instantaneous distribution of the pressure being identical with the stabilised distribution. The consequence of this is that no transient oscillations will be developed due to a travelling surge. A transformer wound in accordance with this principle is known as a non-resonating transformer.

§14. *Generator Surging Due to Short Circuit.*—When a generator is running in parallel with a large supply system of which the phase pressure is maintained at the constant value of V volts, the total power developed by the generator will be

$$W = 3\,V\,.\,I\cos\phi \text{ watts},$$

and since

$$I\,.\,x_a\,.\cos\phi = E\sin\theta,$$

the total power may be expressed as

$$W = 3\,V\frac{E}{x_a}\sin\theta = 6 \text{ (area of the shaded triangle O C B, Fig. 23)} \quad . \quad (1)$$

In these expressions, E volts is the generator induced electromotive-force per phase corresponding to the excitation current and is found from the open-circuit characteristic, and x_a is the synchronous reactance per phase of the generator. The vector diagram for the system will then be as shown in Fig. 23.

The torque τ kg.-m. will then be given by the relationships

$$\tau \times \omega_s \times 9{\cdot}81 = W = 3\,V\,.\,I\,.\cos\phi$$

that is,

$$\tau = \left(\frac{3}{\omega_s \times x_a \times 9{\cdot}81}\right)(I\,.\,x_a)\,(V\cos\phi)$$

and this may be written

$$\tau = C\cdot S\cdot a \text{ kg.-m.} \quad . \quad . \quad . \quad (2)$$

In Fig. 24, R represents the rotor of the generator, which is assumed for clearness to be a two-pole machine rotating at a speed of 50 r.p.s. to correspond to a frequency of 50 cycles. It is assumed that the induced electromotive force vector E is rigidly fixed to the rotor as indicated in Fig. 24. The supply pressure vector V is also assumed to be rotating at a speed of 50 r.p.s., and is displaced from the vector E by the angle θ. It is now assumed that the vectors E and V are coupled by means of a spring of strength C, and extended by the amount S so that the force which is exerted by this spring is

C·S kg.-m.

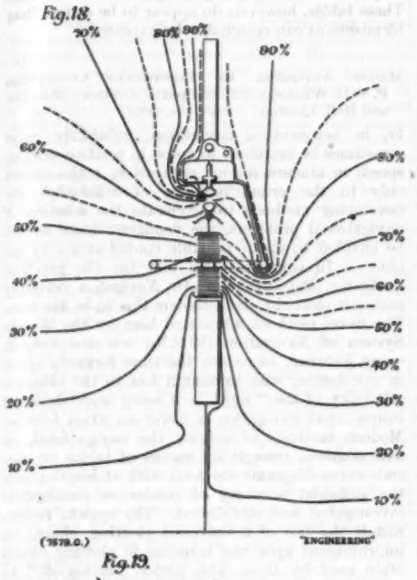
The driving torque which must be applied to the rotor in order to extend the spring by the amount C·S will then be given by the expression

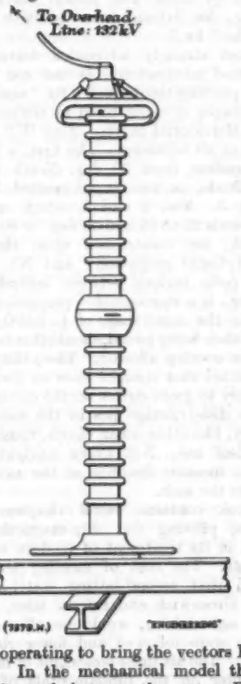
$$\tau = C\cdot S\cdot a \text{ kg.-m.}$$

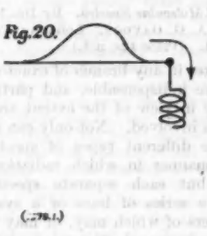
The greater the load on the generator the more the spring will extend and the torque will have to be increased accordingly. By means of this mechanical model, a very helpful general survey of the operation of the generator under various conditions of load can be obtained.

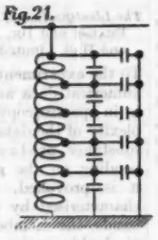
Example 1.—Suppose in Fig. 25 two generators I and II are working in parallel and supplying a consumer at K. The reactances of the lines between the consumer and the respective generators are denoted by x_I and x_{II}, and the respective values of the synchronous reactances are denoted by x_{sI} and x_{sII}. If the phase pressure at K is V volts, the spring model for the vector diagram of the system will be as shown in Fig. 25 (*a*). Suppose, now, that a short-circuit develops at the consumer's terminal K. The pressure V will, in consequence, be reduced to zero and each generator will pump wattless current into the short-circuit, Fig. 25 (*b*). There will consequently be no synchronising torque between the two machines to keep them in step and since each generator will be receiving power from its driving turbine until the steam governor comes into action to cut off the supply, the result will be that each machine will accelerate so that, in general, there will be an increase of the angle θ_d between the two vectors E_I and E_{II}. If the circuit-breaker now comes into operation to clear the short-circuit, the two machines will thereby be connected in parallel, so that a synchronising current can flow between

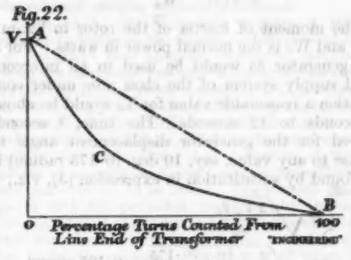
POWER CONTROL IN ELECTRIC SUPPLY SYSTEMS.

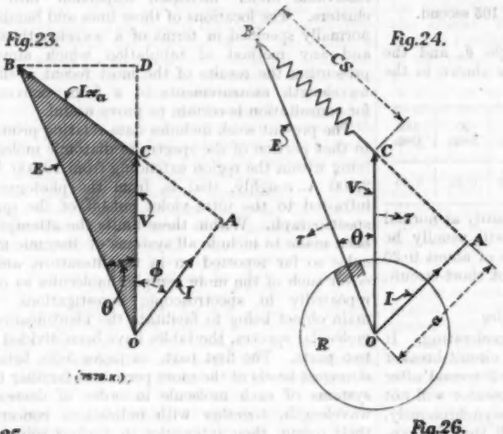


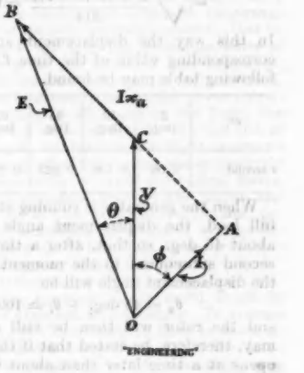


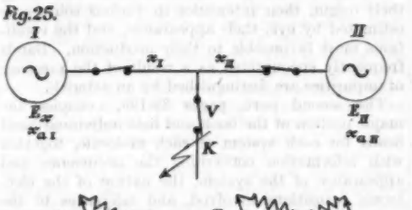


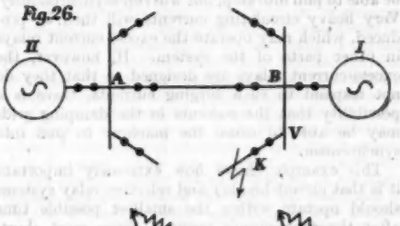


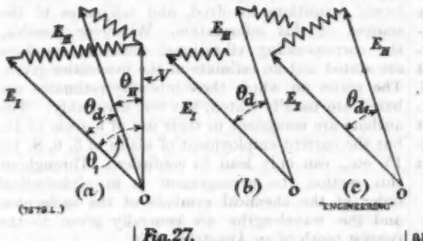


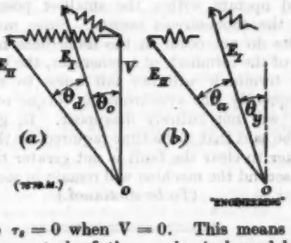


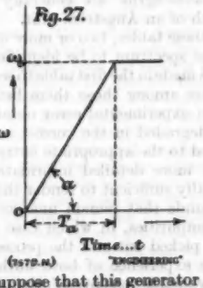












them, thus operating to bring the vectors E_I and E_{II} into phase. In the mechanical model this means that when the angle between the vectors E_I and E_{II} is θ_d the spring coupling will again be established, Fig. 25 (*c*), and the machines will oscillate under the control of the damping grids, and will eventually settle down to a steady running condition.*

It is to be observed in this connection that during the oscillating period the synchronising currents may be sufficiently large to trip the circuit-breaker of one or both machines, which would be very undesirable, since neither the line nor the machines would necessarily be defective. The excess-current relays which control the circuit-breakers should, therefore, be designed so that they will not respond to such surging currents.

Example 2.—Another important practical case is illustrated in Fig. 26, in which two generators are coupled by the link A B, and each is also supplying its own load system. The load on generator I can then be represented by the spring system shown in Fig. 26 (*a*). Suppose that this generator I is supplying its normal full load W_0 when a short-circuit develops close to the machine terminal, as indicated by K in Fig. 26. The pressure vector V at this point will consequently fall to zero, Fig. 26 (*b*), and there will consequently be no synchronising torque to control the generator I. Now at the moment of short-circuit the synchronising torque will be*

$$\tau_s = \frac{d\tau}{d\theta} = \frac{d}{d\theta}\left(\frac{W_0}{9{\cdot}81 \times \omega_0 \times x_a}\right) \text{ kg.-m.}$$

or, substituting for W from equation (1),

$$\tau_s = 3\left(\frac{E_I \cdot V}{9{\cdot}81 \times \omega_0 \times x_a}\right)\cos\theta \text{ kg-m.}$$

and hence $\tau_s = 0$ when $V = 0$. This means that the spring control of the mechanical model will have snapped and the generator I will then pump its supply entirely into the short-circuit at K. Since this current will be almost completely wattless, the load on the generator will be correspondingly small and before the turbine governor can operate to reduce the steam supply, the generator I will accelerate and the angle θ will increase correspondingly (Fig. 26 (*b*)).

This acceleration may be expressed in terms of the "mechanical time constant" T_a, as follows:—The mechanical time constant is the time which would be required for the machine to run up to its normal full speed ω_0 under the action of the normal full-load torque, it being assumed that the whole of the driving energy is absorbed in producing the acceleration; that is to say, there is no load and no retarding friction losses operating to absorb energy. Since the driving torque τ_0 is assumed to remain constant during the acceleration, the speed will increase proportionally with the time (see Fig. 27), that is,

$$\frac{\omega}{t} = \frac{\omega_0}{T_a}; \quad \omega = \frac{\omega_0}{T_a}t = \frac{d\theta}{dt},$$

and, consequently,

$$\theta = \frac{\omega_0}{T_a}\int t\,dt = \frac{1}{2}\frac{\omega_0}{T_a}t^2, \quad \ldots \quad (3)$$

* See also ENGINEERING, vol. 139, page 150 (1935).

* See ENGINEERING, *loc. cit.*

where T_a is the mechanical time constant, viz.,

$$T_a = \frac{J\,\omega_0}{9{\cdot}81\,\tau_0} = \frac{J\,\omega_0^2}{W_0} \text{ second,}$$

J is the moment of inertia of the rotor in kg.-m.^{2} units, and W_0 is the normal power in watts. For a large generator as would be used in an interconnected supply system of the class now under consideration a reasonable value for T_a would be about 10 seconds to 12 seconds. The time, t second, required for the generator displacement angle to increase to any value, say, 10 deg. (0·175 radian) is then found by substitution in expression (3), viz.,

$$t = \sqrt{\frac{2\,T_a\,\theta_t}{\omega_0}}$$

$$= \sqrt{\frac{2 \times 10 \times 0{\cdot}175}{314}} = 0{\cdot}105 \text{ second.}$$

In this way the displacement angle θ_a and the corresponding value of the time t as shown in the following table may be found.

θ_a.	2 Deg.	10 Deg.	45 Deg.	60 Deg.	90 Deg.	180 Deg.
t second ..	0·05	0·105	0·223	0·256	0·31	0·45

When the generator is running steadily at normal full load, the displacement angle will usually be about 45 deg., so that, after a time of about 0·25 second subsequent to the moment of short-circuit, the displacement angle will be

$$\theta_y = 45 \text{ deg.} + \theta_t \simeq 100 \text{ deg.,}$$

and the rotor will then be still accelerating. It may, therefore, be stated that if the circuit-breaker opens at a time later than about 0·2 second after the moment of short-circuit, the generator will not be able to pull into step, but will run asynchronously. Very heavy circulating currents will then be produced, which may operate the excess-current relays in other parts of the system. If, however, the excess-current relays are designed so that they do not respond to such surging currents, there is a possibility that the currents in the damping grids may be able to cause the machine to pull into synchronism.

This example shows how extremely important it is that circuit-breaker and selective relay systems should operate within the smallest possible time after the short-circuit occurs. Since most short-circuits do not occur in the immediate neighbourhood of the terminals of a generator, the pressure at these terminals will not fall quite to zero, and, consequently, the synchronising torque of the machine will not entirely disappear. In general, it may be said that if the time required for the circuit-breaker to clear the fault is not greater than about 0·25 second the machine will remain in step.

(To be continued.)

SOLIDIFICATION TEMPERATURE OF PURE IRON.—The freezing temperature of molten high-purity iron, of more than 99·99 per cent. purity, in an atmosphere of helium has recently been measured by Messrs. W. F. Roeser and H. T. Wensel. Their results are given in a recent issue of the *Journal of Research* of the United States Bureau of Standards. Using an optical pyrometer the temperature was found to be 1,539 ± 1 deg. C. The freezing temperature of 23 samples of irons and steels containing many combinations of 17 elements were also determined. Samples containing less than 0·1 per cent. of impurities were melted in beryllia crucibles and others in alumina crucibles.

THE BOARD OF TRADE AND WAR DAMAGE INSURANCE.—The Board of Trade has set up an expanded and decentralised organisation, in co-operation with the insurance companies and Lloyds, to assist the Insurance and Companies Department of the Board in the settlement of claims which arise under both the Business Insurance Scheme of Part II of the War Damage Act, 1941, and the Commodity Insurance Scheme under Part II of the War Risks Insurance Act, 1939. For this purpose the United Kingdom, which has hitherto comprised 11 districts, has been divided into 31 Insurance Districts (apart from the London Area) in each of which an expert insurance committee has been appointed to supervise the work and make recommendations regarding the settlement of claims. The London area has been divided into four districts working under the general supervision of a committee of management.

LITERATURE.

The Identification of Molecular Spectra. By DR. R. W. B. PEARSE and DR. A. G. GAYDON. London: Chapman and Hall, Limited. [Price 42s. net.]

To the experimenter in any branch of exact science, numerical data are indispensable, and particularly so in spectroscopy in view of the extent and complexity of the data involved. Not only can a single substance produce different types of spectra, depending on the manner in which radiation from it is provoked, but each separate spectrum is characterised by a series of lines or a system of bands, the members of which may, or may not, be resolvable under increased dispersion into line clusters. The locations of these lines and bands are normally specified in terms of a wavelength scale, and any method of tabulation which aims at presenting the results of the most recent available wavelength measurements in a form convenient for consultation is certain to prove useful.

The present work includes data relating primarily to that portion of the spectra of diatomic molecules lying within the region extending from 10,000 A. to 2,000 A., roughly, that is, from the photographic infra-red to the ultra-violet cut-off of the quartz spectrograph. Within these limits the attempt has been made to include all systems of diatomic molecules so far reported on in the literature, and to cover such of the more complex molecules as occur repeatedly in spectroscopic investigations. The main object being to facilitate the identification of molecular spectra, the tables have been divided into two parts. The first part, on pages 5-36, lists the strongest heads of the more persistent familiar band systems of each molecule in order of decreasing wavelength, together with indications concerning their origin, their intensities in various sources as estimated by eye, their appearance, and the conditions most favourable to their production. Bands frequently encountered as a result of the presence of impurities are distinguished by an asterisk.

The second part, pages 38-198, occupies the major portion of the book and lists individual band heads for each system of each molecule, together with information concerning the occurrence and appearance of the system, the nature of the electronic transitions involved, and references to the sources of this information. Wherever possible, the corresponding vibrational quantum numbers are stated and an estimate of the intensities given. The scales on which these intensity estimates are based are usually stated, but not invariably. The authors are consistent in their use of a scale of 10, but the current employment of scales of 5, 6, 8, 10, 15, etc., can only lead to confusion. Throughout this section the arrangement is in alphabetical order of the chemical symbols of the molecules, and the wavelengths are generally given to the nearest tenth of an Ångström unit.

In using these tables, two or more of the strongest bands in the spectrum to be identified are selected and search is made in the first table to see if their wavelengths figure among those there listed. If agreement within experimental error obtains, and if the bands are degraded in the correct sense, attention is transferred to the appropriate entry in the second table. The more detailed information there supplied is usually sufficient to render the identification certain. Bands that remain unaccounted for may be due to impurities, in which case the most prominent are picked out and the procedure repeated.

The wide experience of both authors is evident from the valuable nature of the practical hints which follow the two main tables. They should be carefully studied by any user of the book not thoroughly familiar with spectroscopic technique. A number of representative spectrograms are admirably reproduced. Of these, Plates 1 to 6 contain positive enlargements of 29 selected molecular emission and absorption spectra, Plates 7 and 8, negatives of comparison spectra furnished by the iron, copper and quartz mercury arcs and the neon discharge tube. An appendix includes a list of persistent atomic lines of the elements, arranged in alphabetical order, conversion tables, and the values of certain physical constants. The most important features of any set of tables are comprehensiveness and accuracy, and the realist will rightly maintain that all physical tables resemble directories in that they can never be either quite up to date or infallible. These tables, however, do appear to be as free from blemishes as can reasonably be expected.

Marine Navigation. By LIEUTENANT COMMANDER P. V. H. WEEMS, U.S.N. (retired). London: Chapman and Hall, Limited. [Price 30s. net.]

IF, in aeronautical navigation, reliability must sometimes be sacrificed to speed in position-finding, speed, in modern marine navigation, ranks second only to the prime requisite of reliability. By developing methods to accelerate the solution of navigational problems, the younger science should be enabled to make valuable contributions to the older. In compiling this text for the practical navigator, the author of *Air Navigation* certainly makes it clear that he considers this to be the case. The novel methods advocated here by the Weems System of Navigation (W.S.N.) are designed, in every instance, to reduce the time formerly spent in calculation, with minimum loss to the ultimate reliability of the "sight"—it being understood, of course, that navigation is never an exact science. Modern methods of solving the navigational, or astronomical, triangle by means of tables or altitude-curve diagrams are dealt with at length; and the sufficient accuracy of results so obtained is investigated and established. The system recommends the use of a universal plotting chart, an improvement upon the home-made plotting charts often used by those who prefer "laying-off" to calculating, for laying down position lines and deriving the "fix."

The most strongly advocated feature of this "streamlined navigation" is the use of W.S.N. charts for plotting the derived "fix" and, generally, the advantages of using them in conjunction with the usual Mercatorial charts. Five W.S.N. plotting charts cover all latitudes. The first, a Mercatorial chart extending from 30 deg. North to 30 deg. South latitude, is also supplemented by W.S.N. Chart No. 5. Nos. 2 and 3, which embrace the latitude bands 25 to 55 and 50 deg. to 80 deg. North and South, are constructed upon the Lambert Conformal Conic projection; and No. 4, dealing with the polar regions between latitudes 75 deg. and 90 deg., is a stereographic projection. All five conform to the same scale of 1 : 5,000,000, which permits of their being joined, should that be necessary, despite the overlap allowed. The utility of charts so constructed that straight lines on them approximate closely to great circles on the earth is patent; their only disadvantage lies in the small scale on which they, like other ocean charts, must be printed for practical use. Not every navigator will be content to measure distance at the rate of nearly 70 miles to the inch.

The book contains useful chapters on radio navigation, piloting and ship-magnetism, and is successful in its treatment of modern navigational instruments. The cost of meeting an admirable suggestion that second-setting watches, carrying corrected Greenwich and siderial time, be used to facilitate sight-taking, would be offset if another suggestion were followed and fewer chronometers employed. The air-mass treatment of meteorology, in a chapter on the fundamentals of short-time weather-forecasting, is as excellent as are most American contributions to this science.

Being designed rather as a "refresher" for experienced navigators than as a text-book for examination candidates, the book will appeal more to seniors than to juniors; but, nevertheless, it can be recommended highly to anyone concerned with the practice of navigation, and the ground that it covers should give it unusual value for deep-water yachtsmen. Seamen are a conservative race, in whom monotony gives rise to defensively habitual methods of working, prescribed, too often, by a need to satisfy examiners or superior officers. As Mr. Weems points out, there are many ways of performing the operations that his system promises to simplify; and it is likely to be some time before its influence takes effect upon, for example, the Board of Trade examiners. He has proved it, presumably, in practice before writing this most instructive and readable book.

OCEAN AIR TRANSPORT.*

By J. T. TRIPPE.

(*Concluded from page* 34.)

Accessibility of Power Plants.—In any flying operation, sustained power is a necessity, and in trans-ocean transport it may well prove critical. To reduce the risk of power failures, we have considered for years that the accessibility of power plants in flight would be of inestimable value. It was not, however, until our latest type of Clippers were developed that manufacturers indicated that they could, without serious detraction from design plan, incorporate this feature. The Boeing B-314 aircraft is provided with a companionway on each side of the flight deck leading through the wing to separate stations in the nacelles of each of the four engines. Although we have not won our point entirely, the entire engine not yet being accessible, these stations do provide swift access to the accessory end of each motor. Through these engine stations the flight engineer makes periodic visible inspections of the mechanical functioning of the engines and electrical, fuel and oil systems. He also has available for his periodic inspection all main fuel lines, all control lines, and all interior elements of the wing.

I have no way of measuring quantitatively the value of the accessibility thus permitted; but, during the past two years in which this type of Clipper has been in operation on both the Atlantic and the Pacific, we have had 431 cases of repairs made in flight. The affected power plants were kept going or else quickly returned to operation. In 64 of these cases, had the engines not been accessible, the causes of the failures were of such a serious nature that the ship would have been forced to return to its nearest base with only three of its engines in operation. The safety advantages of power-plant accessibility are obvious. The savings of each such flight completed on schedule—compared with the total loss of revenue production in a schedule failure—is in itself an economic factor of considerable importance. This record, we feel, requires that power-plant accessibility will be in future specifications for ocean transport aircraft.

Scientific Control of Flight.—Given the most expert crews, and the perfect functioning of all mechanical elements, ocean transport flying must be carried out with a high degree of accuracy or it cannot succeed. As a margin for safety, to care for any circumstances which may not have revealed themselves through preflight study of conditions, we require each trans-ocean Clipper of the Boeing B-314 type, when used on flights of 2,000 miles or over, to depart with sufficient fuel to arrive at its destination with a fuel reserve adequate for an additional 4½ hours of flying. This reserve fuel load is a constant factor in all flight-weight computations. What we call the "actual fuel load" is computed after thorough analysis of all foreseeable conditions which the plane must encounter on its planned crossing. Obviously, only after the fuel load is determined, and the mail poundage is provided for, can we arrive at a figure for the allowable passenger and cargo capacity for that particular flight. From any standpoint, the most critical element of ocean flying is fuel consumption. Adequate fuel is an obvious requisite for the safe arrival at destination. Efficient utilisation of that fuel determines the efficiency of the flight itself.

Scientific control of flight may best be explained by describing the construction of an actual transatlantic crossing. For this example, I have selected at random an average schedule—the Yankee Clipper, the eastbound flight of which, on May 13-14, is designated as No. 313 in the operating records of our Atlantic Division The New York to Bermuda stage and the Horta to Lisbon sector are short-range operations and contribute no particular problems. The records I have used are devoted, therefore, to the Bermuda-Horta flight, which represents the critical sector of this route. This particular Clipper had returned from Lisbon to New York on May 11. In the two days intervening before its departure, a staff of 185 mechanics, including some 19 inspectors, operating through three eight-hour shifts, had performed work on and checked some 1,500 separate items required by the maintenance routine. Originally, this process occupied six days. Our present ability to effect it in two days is an important item in our ability to secure an efficient factor of aircraft utilisation.

Before the beginning of each crossing, the crew assigned for that particular flight, accompanied by maintenance and service engineers, inspectors and mechanical specialists, put the ship through a test flight on which air speed and all fuel-flow indicators are calibrated and all compasses are carefully compensated. It is not until the aircraft, as finally tested, has been accepted by the captain, that the plan for the flight is formulated. The first step in this process is the final weather map, which represents the application of the most modern air-mass methods of weather analyses to transatlantic flight problems. Supplementary to this general chart are upper-air weather maps reporting conditions at altitudes of 5,000 ft, and 10,000 ft. A third chart represents a new departure. It is a third-dimensional or vertical weather chart, drawn to provide the pilot with an illustration of what conditions he is to expect and to illustrate the clouds, rain, fog, and icing areas forecast on the route.

From these charts, the meteorologist divides the projected flight line into various zones. Each zone represents an area of more or less consistent winds and the lengths of each are dependent upon the location of the various pressure areas and weather fronts along the route. These zone boundaries indicate the points at which a new track for the aircraft or a new flight level should be selected. From this map and the supplementary charts, the meteorologist then prepares a flight forecast. This reports the state of the weather, the amount, type and height of clouds, the estimated level at which freezing temperatures might be encountered, and wind direction and velocity at 1,000, 4,000, 8,000 and 12,000 ft. In addition, the meteorologist forecasts conditions at the point of destination and all alternates; gives such pertinent information as the location of fronts and the turbulence to be expected in such frontal areas; and points out any icing conditions which are likely to be encountered.

From this flight forecast the captain and the airport manager evolve the Flight Time Analysis. This process considers the complete range of the mechanical ability of the aircraft to the conditions to be encountered or to be detoured either laterally or vertically in each zone. The flight time analysis for the route is calculated for each of the four "primary" altitudes by the use of a computer which quickly gives the ground speed through each zone, determined from the wind, air speed and track projected through that zone. From these ground speeds the time required to pass through each zone and to complete the entire flight can be estimated. From such computations a three-dimensional path of best conditions can be plotted for the flight, designed to yield the safest and most efficient speed, track, and altitude for each section of the route. With the establishment of such a path, an accurate plan of operation is determined. This is finally compressed into the estimated fuel consumption required for the completed flight from terminal to destination.

You will note that this flight time analysis also includes a separate estimate of fuel consumption made for a possible three-engined operation. The three-engined operation data are used to determine our so-called "Point of No Return." Laymen are inevitably intrigued by this fatalistic expression. As a matter of fact, it is merely a designation of that limit-point before which any engine failure requires an immediate turn around and return to the point of departure, and, beyond which, such return is no longer practicable. Fuel-reserve practice insures the ability of the aeroplane to reach the port ahead on three engines in case failure should occur beyond the "Point of No Return."

Upon acceptance of the flight time analysis by the captain and airport manager, the first officer determines what payload can be carried and computes the Weight-and-Balance Manifest. By this method he determines the location for all passengers and cargo so as to obtain the most favourable centre of gravity for the take-off, flight and landing. The third officer's duty is to assemble the various clearance manifests required by the Governments along the route. The flight engineer proceeds with the fuelling and servicing of the plane according to the detailed figures resulting from the flight time analysis. The B-314 has a total tank capacity for 5,400 gallons of fuel. Operating gross weight on all long-range flights is invariably 84,000 lb. After all the technical data have been compiled, as a last check on crew co-ordination a crew meeting is held immediately before departure, to review with each member the positions of all emergency equipment on the aircraft; and an individual recitation drill is held on the correct procedure for each man for all emergencies, both in the air and on the water.

We are now ready for departure. The take-off is accomplished with the captain controlling the throttles and control surfaces, and the first officer manning the flaps and the short-range radio telephone to the stand-by launch. During the take-off, the flight engineer constantly checks cylinder-head temperatures, and oil and fuel pressures. Take-off power is 1,550 h.p. per engine at 2,400 r.p.m. The manifold pressure is 42½ in. Take-off under normal conditions requires approximately 30 seconds from the time full power is applied until the aircraft leaves the water after a run of approximately half a mile. After the take-off, the aircraft is held immediately above the water until an air speed of 105 knots is reached, at which point full manœuvrability of the ship on three engines is assured. The engines are then pulled back to 1,200 h.p. each. This output is maintained by the flight engineer until all obstacles in the area are adequately cleared, generally at a height of 500 ft. to 1,000 ft. At this point the engines are again throttled back to their climbing horse-power of 900, and 110 knots is maintained until the selected cruising altitude is reached.

Once aloft, the flight-deck routine is conducted strictly in terms of the mechanical conditions imposed by the flight time analysis, which, in turn, is based upon the tabulated analysis of the performance of the aircraft under the given combination of circumstances. It becomes a primary duty of the captain to study the reports of his second officer and flight engineer for any indication of conditions which might require modification of that flight plan. Any variations of the power plants or accessories, beyond certain prescribed limits, are immediately to be noted. Track made good compared with the projected course is also indicated, as are any serious variations in forecast weather. Against this background of estimated and actual progress of the flight, the captain endeavours at all times to keep the aircraft flying under our standard long-range cruising formula at its most efficient airspeed; that is, at the speed which will give the maximum miles of ground speed progress per gallon of fuel consumed. As the gross weight diminishes in ratio to fuel consumed, he must therefore continually reduce the power output in order to maintain, at all stages of the flight, the wing's most efficient angle of attack. At the end of this particular flight, for instance, the flight engineer's log shows that the speed of the engines was successively cut to 1,200 r.p.m. as the aircraft approached Horta. Because the gear reduction between the engine and propeller is 16 to 9, the propeller revolutions per minute under this condition are reduced to approximately 675, at which speed the 14 ft. 10 in. propellers appear to be moving very slowly indeed.

Thus is each transatlantic flight planned and conducted, but all the planning in the world would be useless unless it is executed with accuracy. To execute a plan accurately, it is necessary to have in hand an easily usable yardstick of performance. We have developed such a yardstick, which bears the very American title of a "Howgozit Curve." This is no mere pilot's nickname. It has now become a formal designation for this type of chart by our engineering department. The "Howgozit Curve" was developed by our ocean captains under the leadership of Captain Harold Gray, now Chief Pilot of our Atlantic Division. Its purpose is to present to the crew aloft and the flight watch ashore a continuous flow of information as to the fuel reserve remaining aboard the aircraft and the fuel required for completion of the flight to destination, or back to the point of departure. Actually, it consists of five curves which are required to present this picture clearly. Using the path selected in the flight forecast and performance charts for the plane and its engines, a curve of miles against gallons is plotted, showing normal four-engined fuel consumption for the flight in hand. The second curve shows gallons against hours of flying. The third curve is of hours against miles. Since we must assume that three-engined operation may be made necessary at any time, the fourth and fifth curves, showing miles against gallons, are also plotted for three-engine "ahead" and "return" conditions. Also on the chart at this time is plotted the "Point of No Return," which has been previously mentioned.

All of these curves are drawn in solidly to indicate that they are based on the flight time analysis. As the flight proceeds, a constant record of the plane's actual fuel consumption is maintained. It is the first officer's duty to draw alongside these solid forecast curves, dotted curves which indicate the actual performance of the plane. Deviations to one side or the other simply and quickly indicate to the captain, as well as to the flight watch officer at the terminal, whether the flight is proceeding satisfactorily, or whether some factor, such as changing wind condition, is raising the fuel consumption, and at what rate that fuel consumption is being raised. The chart is of extreme value in forming any decision as to the desirability of modifying at any point, the track, the altitude, or of actually breaking off the flight for a return to the point of departure.

The flight I have described is purely typical from a technical viewpoint. Other flights, of course, have had to consider other weather, wind and altitude factors. Some have plotted and executed detours of several hundred miles in mid-ocean to avoid predicted areas of high intensity storms. One flight on the mid-Atlantic Route in mid-winter actually made its scheduled crossing in a few minutes less than 24 hours in the teeth of head winds which averaged 41·9 miles per hour for the entire course. Each flight, I can safely say, has made some contribution to our technical knowledge of the Atlantic and its exacting conditions in this first two years of service. But despite these difficult conditions, we feel that the transatlantic airline has rendered an important service. Individual mail loads of 13,000 lb. and passenger loads, in addition to mail, of 33 eastbound and 35 westbound have been

* 29th Wilbur Wright Memorial Lecture, delivered before the Royal Aeronautical Society, in London, on June 17, 1941. Abridged.

transported. We are particularly gratified that, although the war has transferred to the aeroplane some 30 per cent. of the total transatlantic mails, our service has been able to carry all offered us by the postal authorities. Furthermore, the Clippers have consistently transported representatives of Government and industry whose missions were of importance to your country as well as to our own.

Nor, during this period, has Pan American been unmindful of its responsibility to carry forward the further development of this trans-oceanic service. Hardly had our initial schedules been instituted with the 84,000-lb. Boeing B-314 Clippers when specifications were released to manufacturers inviting their bids on the design and development of a new type of Clipper which our experience indicated to be the required next step in trans-oceanic development. Construction contracts for such aircraft were actually let in June, 1940, with the first deliveries scheduled for early in 1942. I regret that I am not yet at liberty to disclose, here or at home, the technical details of these aircraft. I can, however, cite certain of the immediate and specific problems encountered in our transatlantic operation, the presence of which we had in mind in their procurement.

(1) During the months between October 1 and April 1, sea swells in the harbour of Horta exceeded 3 ft. on 35 days out of each hundred, and exceeded 2½ ft. on 57 days out of each hundred. The effective solution of this cause of delayed schedules is an advancement of the practical commercial range of trans-oceanic aircraft so as to permit the Continent-to-Continent non-stop operation. (2) The consistently high velocity of westerly winds, particularly during the winter months, contributes not only to schedule cancellations but, even when such flights are technically feasible, imposes unreasonable restrictions on payload. Wind-aloft records maintained through the past two years indicate that higher cruising speeds, of at least 75 to 100 miles an hour greater than those now available, are desirable. (3) Finally, the recurring ice problem on the North Atlantic coast points to the advantages of landplane operations. Landplanes could also permit direct service between metropolitan airports on both sides of the Atlantic.

Let me emphasise once more that the aircraft of which we are now awaiting deliveries are by no means anything which I would think of offering as "the ideal" transatlantic aircraft. It will be many years before depreciation and not obsolescence will be our concern. We have immediately before us advancing researches in such fields as boundary-layer control, exhaust-heat utilisation, and unorthodox power plants—to mention just a few. Substantial advancement of ocean air transport, however, is by no means dependent upon further revolutionary developments. Refinements of details are productive of far-reaching results. The need for efficiency distinguishes a long-range ocean transport from other civil aircraft. For example, the latest type short-range landplane, the Douglas DC-3, can make a flight of 750 miles with 45 minutes' fuel reserve, carrying a full load of 21 passengers. For such a normal assignment this aeroplane carries a fuel load of 450 gallons, weighing 2,700 lb., which represents only 11 per cent. of its gross weight, or 33 per cent. of its useful load. By comparison, the Boeing 314, operating over a route of 2,400 miles, with 4½ hours' fuel reserve, requires 4,000 gallons or 24,000 lb. of fuel, which constituents 29 per cent. of its gross weight and 73 per cent. of its useful load. If some means can be found to increase the efficiency of the DC-3 by 1 per cent., this would increase its payload by only 27 lb. If a corresponding increase of 1 per cent. could be made in the efficiency of the Boeing 314, however, we should gain no less than 240 lb., or slightly more than the allowance for one passenger. Effort and expense are continuously justified for research whereby such efficiency improvements can be achieved.

Of one thing we can be sure in this uncertain world—the advance of aircraft design is in dynamic forward motion. We can, I feel, look forward to wing loadings of 80 lb.; aspect ratios of 11; useful-to-gross weight ratios of 50 per cent.; and efficient 3,000 h.p. engines are in prospect. With advances such as these in the offing, who would be bold enough to predict the distant future? In these past two years transatlantic passenger service has already become a fact. It is no longer an adventure. It has become a vital link between the new world and the old. Before the next two years have passed, I believe we can, with confidence, look forward to frequent daily flights, operating on 12-hour schedules, to bridge what was once a great barrier ocean and to bring our two great democracies into still closer union.

WORK OF BRITISH LIFEBOATS.—The Royal National Life-Boat Institution, Boreham Wood, Herts, informs us that 3,816 lives were rescued by lifeboats in the British Isles during the first 21 months of the war.

120-KVA FLASH BUTT-WELDING MACHINE.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

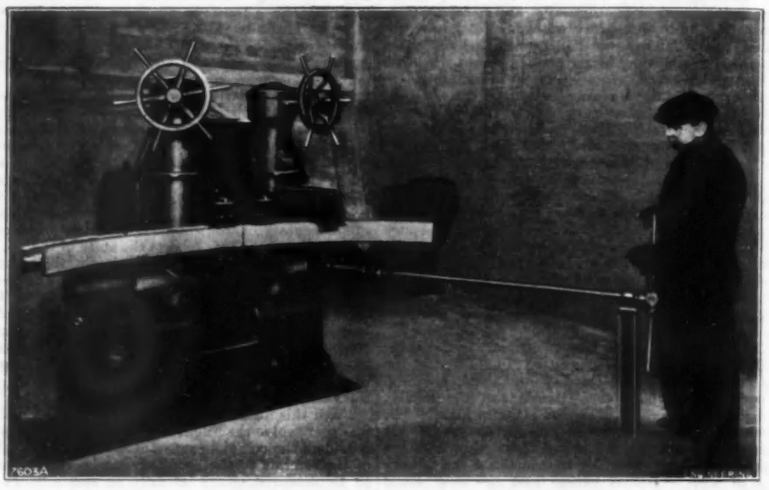


FIG. 1. MACHINE INSTALLED IN COLLIERY OF MESSRS. THE WEMYSS COAL COMPANY, LIMITED.

120-KVA FLASH BUTT-WELDING MACHINE.

UNDER present conditions, it is particularly important that no material should be scrapped when a simple repair with the minimum of new material will produce or reclaim a serviceable article. Welding processes have been used in a variety of ways with this object in view, and the welding machine described below merits attention for its utility in this direction. Flash butt-welding machines can make homogeneous joints in rolled-steel sections or tubes and are both quick and reliable in operation. No special machines are required for the preparation of the work prior to welding; neither are there any expensive finishing processes.

Briefly, flash butt welding is a process of welding by bringing together the ends of two parts carrying a heavy current and separating them several times. One of the two parts is held in fixed jaws and the other in movable jaws. The current is switched on and the two surfaces to be welded are brought together by the movable jaws. Current flows through the joint and causes it to heat up, but when heated to redness the bars are separated again and the partly-joined surfaces are torn apart. This butting and separating procedure is repeated several times, so that all projections and impurities are burned away and the faces of the joint are brought up to a bright red heat uniformly over their whole area. At this stage, the flashing operation is started by separating the surfaces once again and bringing them together slowly so that a continuous flash is produced from the joint. This flashing is repeated until a predetermined amount has been burned off the ends of both bars and the two surfaces are then pressed together, or up-set, under a high pressure and the welding current switched off.

There is a considerable field of application for flash butt welding in the coal-mining industry, in which the reliability and strength of this type of welded joint are essential. An interesting example of such an application is in the repair of colliery roof supports. These consist of 5 in. by 4½ in. H-section steel joists bent to form an arch; the largest arch being 12 ft. by 9 ft., and the smallest 6 ft. by 6 ft. Under the severe service conditions encountered in mines, some of these arches become bent and torn, and formerly when this occurred such arches were scrapped and replaced by new ones. Now the damaged arches are removed from the pit, the defective parts cut out, and new lengths of joist bent and then flash butt-welded in place of the discarded pieces. The short ends of lengths of joists, which are normally scrapped, can be welded up to give any continuous length required for the construction of new arches. This method of repair of steel roof arches is being used in a number of collieries and, we understand, has proved entirely satisfactory.

Flash butt-welding machines, constructed by Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, have been installed in the collieries of the Wemyss Coal Company, Limited, for the purpose referred to above, and Fig. 1, on this page, illustrates one of these machines, which is shown on a larger scale in Fig. 2, opposite. It has been designed to butt weld solid steel sections of from 1 sq. in. to 8 sq. in. across sectional area. The welding current is supplied by a 120-kVA water-cooled transformer mounted in the fabricated steel frame of the machine. The special method of construction of the water-cooled secondary winding of this transformer enables it to be operated indefinitely at its maximum output without over-heating. Five taps are provided on the primary winding, and connected to a five-position tapping switch, mounted in the side of the machine. This enables the necessary variation of welding current for the different sections to be obtained. A contactor, mounted in the machine frame and controlled by a foot-switch placed near to the operator's position, is used for switching the welding current on and off.

The general arrangement of this machine is shown in Fig. 2. The clamping of the jaws is carried out by handwheels through gearboxes and screw mechanism, designed so that the high clamping pressures necessary for the larger sections can readily be obtained. The detachable copper clamping jaw blocks and the connections from them to the transformer are adequately water-cooled. One set of work clamps is fixed to, but electrically insulated from, the machine frame, while the other set is free to slide in the horizontal direction on a substantial circular guide shaft, this movement being controlled by the up-setting handwheel through a gearbox and screw. The up-setting mechanism has been designed so that the high up-set pressure required to form sound welds on the larger sections can be attained with ease. An indicator attached to the gearbox gives a direct reading of the horizontal movement and is used during the flashing period to determine the amount of "burn-off." All parts, both mechanical and electrical, likely to be affected by the molten particles thrown out during the flashing operation, have been provided with substantial metal guards as shown in Figs. 2 and 3. Each water-cooling circuit on the machine is provided with a separate control valve and drains into an open drain box, so that there is a visual indication of the flow.

We are indebted to Messrs. The Wemyss Coal Company, Limited, for permission to publish this article and for some of the information it contains.

BETHLEHEM STEEL COMPANY.—The production capacity of the rod rolling mill at the Maryland Works, U.S.A., of the Bethlehem Steel Company has recently been doubled and it is now capable of producing 1,000 tons of material in 24 hours.

EXPORTS OF MANGANESE FROM BRAZIL.—According to figures published by the Guaranty Trust Company of New York, exports of manganese from Brazil during January and February, 1941, totalled 57,390 tons. During the whole of 1940 shipments amounted to 211,364 tons, as compared with 188,306 tons in 1939. Increasing quantities of the product are reaching markets in the United States.

120-KVA FLASH BUTT-WELDING MACHINE.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

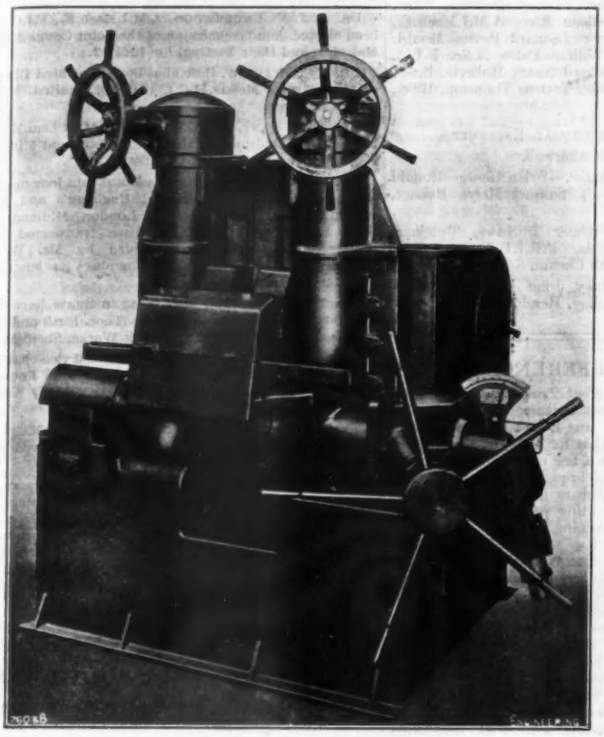


FIG. 2. GENERAL VIEW OF MACHINE.

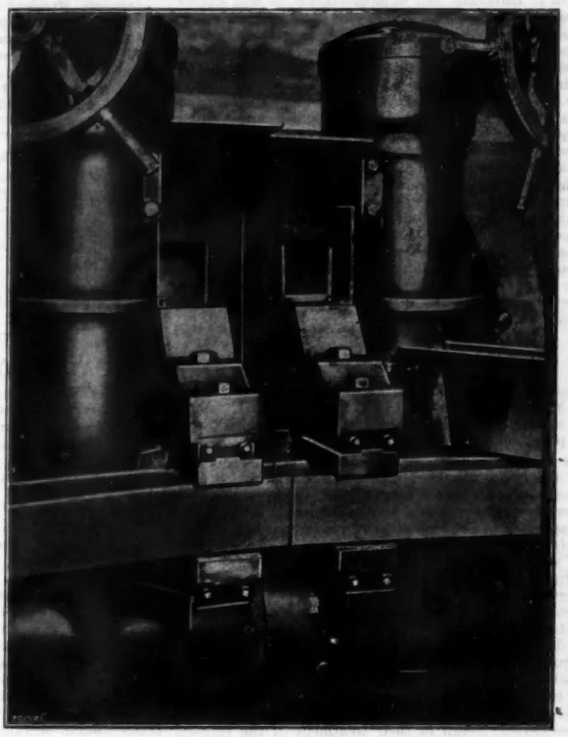


FIG. 3. CLAMPING JAWS OF MACHINE IN USE.

THE FUTURE OF THE GAS INDUSTRY.*

By GEORGE DIXON, B.Eng., M.Inst.C.E.

FOR well over a century the gas industry has been developed by engineers who have exercised their individuality along lines that have allowed considerable latitude in manufacture and distribution. The ingenuity practised has been limited only by such legislation as has been imposed by Parliament to safeguard the interests of consumers. Because of our long establishment, the general public may envisage us as an industry fully developed and settling down to an uninteresting life of present-day standard and limited future prospects. Fortunately such an outlook is entirely contrary to the true state of affairs, for a new horizon has been formed as the result of an appreciation of the value of co-operation with our chemical friends and with other bodies interested in modern methods of coal carbonisation.

It is true that, as most of us are engaged as controllers of public utility undertakings, our consideration of present-day gas-works practices and the problems of utilising the products of carbonisation invariably turns to economics and to the effect of variations of the quantities and values of gas, coke, tar, benzole, etc., and the incidence of these severally upon the cost per therm of gas to the consumer. Here the study becomes complicated, because we are faced with the necessity of deciding whether our first consideration, from the national view-point, is to obtain the best results from the coal, or to approach the survey purely from the requirements of the gas consumer. Unfortunately, our loads are partly seasonal, and national requirements contain many variables, it therefore becomes exceedingly difficult to frame a fixed policy of carbonisation that will meet the requirements at all periods of the year and still leave satisfactory conditions for all concerned.

Our industry is rich in scientific enthusiasm, and the necessity for the newly-formed Gas Research Board is a result of the urgency of investigating co-operatively the highly technical and academic problems that have arisen from preliminary suggestion. The reports of research workers, and the work still quietly proceeding in laboratories or in experimental plants at Leeds University, the Fuel Research Station, and other technical centres, would appear to indicate the possibility of many progressive changes in the industry, and it is indeed regrettable that so much important work has had to be slowed down, or even interrupted completely, in favour of work demanded by the most destructive war in history.

Much could be written of war experiences and of our contribution to the national effort, but I suggest that we confine our attention in this address to the preliminary considerations of post-war problems and reconstruction. I am somewhat fearful of the word "reconstruction." To me, it is a dangerous word—a hackneyed expression, glibly used to-day by all sorts of speakers and at all kinds of meetings. It is meaningless and even harmful unless qualified, carefully understood, and accompanied by practical effort. What then do we mean by "reconstruction"; who is to do the work involved; and when is it to commence?

I hope we mean a determination to make a critical analysis of our industry, technically, economically, socially, and financially, and an equal determination to see that nothing but the best practices for the benefit of the country, the consumers and the personnel engaged are permitted. Some of the changes that would appear to be due have been justified already by scientific findings or proved by practical experience; some have been revealed by recent war experiences, while others, I fear, have been "excused" by some undertakings on the grounds of lack of capital, doubt of the economic results, lack of adequate technical staff to supervise new practices, or even a desire to leave well alone and save the trouble of a little extra exertion to start up new methods. In many cases an economic balance sheet for a process can only be made out after a full review of the cost of the process and the results on the district either through reduction in distribution costs, better working of the appliances, or, most important, an improvement in consumers' goodwill. Surely, where any modern adjustment of practice can be proved to be an advantage to the prestige of the industry, it should not be permissible for some undertakings to adopt the practice and others to reject it.

Experience prompts the conviction that the potential strength of available technical brains is not being fully utilised. The universities and the Institution's education scheme are training young capable men who are necessary for the investigation and operation of modern works plant. The older men must give these qualified members of our staffs more encouragement and more freedom to exercise their skill and individuality; there are many cases where controlling bodies view adequate qualified staff purely as an additional expenditure. This is a dangerous and near-sighted policy; modern gas plants are very costly, and proper practical and technical control results in considerable savings, equal to several thousands of pounds per annum per million cubic feet per day capacity.

The provision of adequate qualified staff is the first essential for every company or municipal undertaking, from the largest to the smallest. This is not a revolutionary change from present practice so far as numbers are concerned, as my experience suggests that it is the quality rather than the number of technical staff that is the weakness. Those concerns which are not of sufficient size to employ such men as are requisite must be dependent upon assistance from others in the neighbourhood. Such an organisation must be one of the first items of our reconstruction policy; there has been sufficient evidence in recent years of the beneficial results to be obtained from a pool of technical staffs within convenient areas.

One of the most valuable concessions granted to us by the Government over the past 20 years has been the freedom of choice of plant and of the calorific value of the resultant gas made. Since the choice of coalfields, however, has now been limited through the operations of the coal selling schemes, it may be that the time has come to consider whether some reduction of the number of gas qualities is desirable, within those areas served by similar classes of coals. Such consideration is closely linked with the tendency and desirability of physical linking-up of neighbouring gas supply authorities and the tightening-up of the specification for a more satisfactory smokeless fuel product. A decision on these questions might helpfully lead to further standardisation of plants and meters and appliances.

I believe that greater uniformity with regard to benzole washing, gas drying, sulphur removal, distribution pressures and practice is worthy of very careful analysis and might easily result in greatly increased sales of gas. Sufficient experience has been gained during recent years for recommendations to be made

* Presidential address to the Institution of Gas Engineers, delivered in London on June 11, 1941. Abridged.

in these and other matters—recommendations which should be accompanied by some means of ensuring their adoption by all; otherwise there remains the old anomaly of different practices in different districts.

Who is to do the work involved in the reconstruction? Obviously the implementation of any agreed recommendation must come from within the industry. Reference to the plan of the organisation of our Institution will show how well placed we are, fortunately, for obtaining the views of all sections of our technical and administrative workers. In addition, we are linked to the other national bodies on the legal, publicity, and employees' sides. The District Senior and Junior Associations are loyal, united, and exceedingly virile, and they each represent a view-point which must be taken into account in the framing of a future policy. The committee best suited to undertake the complete survey of the industry should be representative of all existing national and district organisations, strengthened by representatives of domestic and industrial consumers and of the Board of Trade. The time for commencing the preliminary work of reconstruction, by giving careful thought to the problems to be met and the procedure to be adopted is, without doubt—*now*.

NOTES ON NEW BOOKS.

Time and Motion Study. Third edition. By STEWART M. LOWRY, HAROLD B. MAYNARD and G. J. STEGEMERTEN. London: McGraw-Hill Publishing Company, Limited. [Price 35*s*.]

AT the present time, many firms who have been asked to undertake the manufacture of goods of which they have no previous experience, and, consequently, no records of performance, are finding some difficulty in realising the full possibilities of production in a reasonably short time. The present book, the previous edition of which was reviewed in our issue of May 18, 1934, appears to be based on the primary assumption that very large quantities of goods are to be subjected to the processes requiring investigation. This condition obtains to-day to a greater extent than ever before, and the interest of the book to British readers, therefore, should be correspondingly enhanced. The authors are practical men, with first-hand experience of time and motion study as applied to mechanical and electrical engineering manufactures, and they go into considerable detail in their treatment of the subject. The latter part of the book is devoted to the collation of the data obtained, the development of formulæ to represent the complete operations, and the determination of the necessary constants. There may be some differences of opinion regarding the utility of these methods of computing wage incentives, as applied to British conditions; but the proposals are not of a wholly theoretical character, and, in suitable cases, might well repay investigation.

Handbook of Workshop Calculations. London: H.M. Stationery Office. [Price 3*d*. net.]

THIS useful little book appears under the joint auspices of the Board of Education and the Ministry of Labour and National Service. Normally, it may be presumed, the duty of these departments does not include the preparation of elementary text-books, but present circumstances are so far from normal that the publication may be accepted without demur. Each of these bodies is closely concerned with the training of large numbers of new workpeople for engineering shops, and although the majority of these will not be required to occupy themselves with workshop calculations of any kind, an important minority, which includes youths definitely entering on an engineering career, is likely to find a knowledge of elementary workshop calculations of practical value. The handbook does not contain anything which cannot be found in school arithmetics or text-books on practical mathematics, but the presentation of such elementary parts of these subjects as are likely to find direct application in machine work and fitting is a convenience likely to be widely appreciated at the present time. Wise selection has been exercised by Dr. Chapman, Head of the Engineering Department of the County Technical College, Wednesbury, who was mainly responsible for the compilation of the book, and by restricting it to matter of immediate application has produced a slim publication which will not intimidate the class of user for whom it is intended. A booklet twice the size would probably have taught less by attempting to teach more. The handbook begins with a little simple arithmetic, with useful guidance on approximations and the value, or otherwise, of working to many decimal places. This is followed by instructions on the calculations of areas, weights and volumes of round and rectangular forms, with a good collection of worked-out examples of more complicated shapes. A conversion table, connecting vulgar fractions, decimals and metric measure, is provided at the end. The small price of the handbook should result in a wide circulation.

INSTITUTION ELECTIONS.

INSTITUTION OF CHEMICAL ENGINEERS.

Member.—George Stanley Haslam, B.Sc., Ph.D., Denaby; George William Sinclair, London, E.C.2.

Associate Member.—Ieuan Thomas Griffiths, B.Sc., London, E.3; George Neilson Klee, A.M.I.Mech.E., a Royal Ordnance Factory; Leonard Pearce Mould, London, S.W.1; Edward William Pates, M.Sc., F.I.C., Greenford, Middlesex; Richard Henry Roberts, B.Sc., Ph.D., London, S.W.1; John Francis Thomson, B.Sc., A.I.C., London, S.E.17.

INSTITUTION OF STRUCTURAL ENGINEERS.

Member.—Elijah Page, Motherwell.

Associate Member to Member.—Brian George Ronald Holloway, Woking, Surrey; Samuel Melya Reisser, London.

Associate.—Thomas Mortimer Burrows, Twickenham; John Lewis Curtis, F.R.I.B.A., London; Leonard Shaw-Davis, North Cheam, Surrey.

Associate Member.—Sidney John Pells, Sheerness, Kent; Alfred Leonard Wolley, Hendon.

ANNUALS AND REFERENCE BOOKS.

Colliery Year Book and Coal Trades Directory, 1941.—We are glad to find that in spite of difficult conditions resulting from the war it has been possible to publish the 19th edition, that for 1941, of *The Colliery Year Book*, and that, with a few exceptions, the information contained has been brought up to date. For obvious reasons, the publishers have been unable to give recent statistics regarding production, etc., but the position of the coal-mining industry and of the coal trade have been reviewed as usual and a new section dealing with war-time conditions and regulations has been added. The arrangement of the volume follows established precedent. The longest section is the directory of colliery undertakings in Great Britain. This includes, in addition to the name and addresses of each firm, the names of the directors and principal officers, the name and location of individual pits, the number of employees, the seams worked, the class of coal mined, the annual output, and the type of power used. The coal-trades directory comprises twelve sections dealing with coal merchants exporters, shippers, contractors, factors, agents, etc. Other sections in the volume relate to Mines Regulations, blasting in collieries, coal marketing schemes, and bibliographies of periodicals and books on coal mining. An official section, containing data on Government Departments and associations, institutions and federations connected with coal and coal mining; lists of gasworks and electricity-supply undertakings; and a useful "Who's Who" in the coal-mining industry, are also included. The book is published by Messrs. The Louis Cassier Company, Limited, 18, Loom Lane, Radlett, Herts., and the price is 1*l*. 1*s*. net.

BOOKS RECEIVED.

Producer Gas for Road Transport. The Design and Operation of Producer Gas Vehicles and the Regulations and Taxation Affecting Them. By BRIAN REED. London: "The Railway Gazette" Offices, 33, Tothill-street, Westminster, S.W.1. [Price 6*s*. net.]

Technology for Sugar Refinery Workers. By OLIVER LYLE. London: Chapman and Hall, Limited. [Price 15*s*. net.]

United States Coast and Geodetic Survey. Serial No. 632. *The Preservation of Triangulation Station Marks.* Washington: Superintendent of Documents.

University of Illinois. The Engineering Experiment Station. Reprint Series No. 21. *Seventh Progress Report on the Investigation of Fissures in Railroad Rails. Conducted in Co-Operation with The Association of American Railroads and the Rail Manufacturers' Technical Committee.* By H. F. MOORE. Urbana, Ill., U.S.A.: The Director, The Engineering Experiment Station, University of Illinois. [Price 15 cents.]

University of Illinois. The Engineering Experiment Station. Bulletin Series No. 326. *An Analytical and Experimental Study of the Hydraulic Ram.* By PROFESSOR W. M. LANSFORD and W. G. DUGAN. [Price 70 cents.] Bulletin Series No. 327. *Fatigue Tests of Welded Joints in Structural Steel Plates. A Report of an Investigation Conducted in Co-Operation with The Public Roads Administration, Federal Works Agency; The Chicago Bridge and Iron Company; and The Bureau of Ships, U.S. Navy.* By W. M. WILSON and others. [Price 1 dollar.] Bulletin Series No. 328. *A Study of the Plate Factors in the Fractional Distillation of the Ethyl Alcohol-Water System.* By PROFESSOR D. B. KEYES and LEONARD BYMAN. [Price 70 cents.] Urbana, Ill., U.S.A.: The Director, The Engineering Experiment Station, University of Illinois.

PERSONAL.

SIR GEOFFREY PETO, K.B.E., has been appointed regional representative of the Ministry of Supply in the Southern Area. MAJOR C. C. B. MORRIS has received a similar appointment in the Eastern Area.

DR. A. J. V. UNDERWOOD, A.M.I.Mech.E., F.I.C., has been elected deputy-chairman of the Joint Committee on Materials and their Testing, for 1941-42.

DR. J. C. SWALLOW, B.Sc., has been appointed Director of Research by Messrs. I.C.I. (Alkali), Limited, Northwich, Cheshire.

MR. T. H. GANT, A.R.C.Sc., A.I.C., M.I.Chem.E., has been elected chairman of the Birmingham and Midlands Section of the Institute of Chemistry.

MR. W. MARSHALL, district assistant (outdoor machinery services), Chief Mechanical Engineer's and Electrical Engineer's Department, London Midland and Scottish Railway, Crewe, has been transferred to a similar position, hitherto occupied by Mr. W. M. Chambers, at Manchester. Mr. Chambers has succeeded Mr. Marshall at Crewe.

MR. E. J. LOWE and MR. WALTER SHAW have been appointed local directors of Messrs. Thos. Firth and John Brown, Limited, Atlas and Norfolk Works, Sheffield, 1.

COLONEL W. H. WIGGIN has been elected vice-chairman of Messrs. W. and T. Avery, Limited, Soho Foundry, Birmingham. The general manager, MR. AUSTIN MORLEY, has been elected to the board.

The Sheffield offices of MESSRS. PEAT, MARWICK, MITCHELL AND COMPANY have been transferred from Church-street to 301, Glossop-road, Sheffield, 10.

MR. FRANK T. SISCO has been appointed assistant secretary of the American Institute of Mining and Metallurgical Engineers and secretary of its Iron and Steel and Institute of Metals Divisions, in succession to MR. LOUIS JORDAN, who has joined the U.S. Government Service in Washington. Mr. Sisco is well known in this country as Editor of several monographs of the American Alloys of Iron Research.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The effort to increase production in the South Wales mines continued unabated last week. A number of speakers attended a special conference of the South Wales Miners' Federation and urged on the men the necessity, in the national interest, of increasing the output. Mr. D. R. Grenfell, Secretary for Mines, one of the speakers, said that the Government wanted from the miners this year an output which was about 150,000 tons less than the high water mark. Mr. Arthur Horner, President of the Federation, referred to a suggestion that had been made that the working hours at the mines should be increased. He pointed out that the men were producing more per man shift in 7½ hours than they did with longer hours in the last war. He added that neither the owners nor the Mines Department nor any responsible authority was putting forward the suggestion of lengthening the working day, and concluded by remarking that South Wales miners, given a square deal, would give the country all that it was asking for. Among the items discussed at the conference were holidays, Sunday work and the non-unionist question. Terms of payment for Sunday work were accepted by a small majority for submission to the lodges. The lodges promised to report their decisions on the matter to the head office by July 16. Conditions showed little variation on the steam-coal market during the past week. Supplies of all the more favoured kinds were still extremely difficult to secure, especially for early delivery, and as the demand failed to show any falling off the general tone was again very firm. Best large sorts were only very sparingly offering for early delivery and the sized kinds were in strong demand. Bituminous smalls were also a strong feature and practically unobtainable for some time to come. Dry steam smalls however, were again in plentiful supply to satisfy a slow request and were consequently dull. Cokes and patent fuel were unchanged.

The Iron and Steel Trade.—Activities in the iron and steel and allied trades were well maintained last week. The demand continued active but producers could accept little fresh business as the works were kept fully occupied with orders already in hand.

THE RATIONING OF MOTOR FUELS.—The Secretary for Petroleum has drawn up a new Direction under the Motor Fuel Rationing Order, 1941. This Direction (S.R. & O. 1941, No. 834, price 1*d*.), gives effect to the provision of the Order prohibiting the acquisition, or supply, of motor fuel for private cars or motor cycles against coupons issued for industrial and agricultural purposes, or in respect of commercial vehicles.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Increased outputs are reported by all the staple trades in this area, but further expansion is expected during the next few weeks. In the raw and semi-finished steel-producing branches the position shows no appreciable change. The outputs of all types of materials are increasing, and no difficulty is being experienced in obtaining ample supplies of pig iron, hematites, and steel-making alloys. The scrap situation is satisfactory. Structural steel is in strong demand for various purposes; engineering works are ordering heavy sections and joists. Orders for billets, strip and rods represent a heavy tonnage in the bulk, and the consumption of ferro-alloys is considerably greater than was the case a year ago. Rolling mills, forges, and press shops are working at full capacity, and foundries are accounting for increased outputs. Orders for heavy engineering products and machinery products are more numerous, and inquiries are also coming to hand, on home account, in increased numbers. Railway rolling stock departments are busier, a considerable trade being done in wheels, axles, springs and tyres. The demand for buffers continues to increase. Shipbuilding requirements are in increasing demand, among the items needed being machinery and engine parts, deck furnishings, and tools. The medium sections are also well occupied. Light types of grinding and crushing machinery are in demand by quarry owners and building contractors, many of whom are engaged on Government work and are carrying out extensions to steel and engineering works. Mining equipment is in better demand, and makers of electrical plant are doing an extensive trade. Progress has been well maintained in the production of all kinds of agricultural machinery, machine parts, and implements. Tool makers are exceptionally busy, and are accounting for large outputs.

South Yorkshire Coal Trade.—There is a tendency for outputs to increase at many collieries, and the general demand for coal has been well maintained. Industrial coal is moving in record tonnages. Railway companies are also buying heavily for stocking purposes, and electricity and gas undertakings are adopting a similar policy. The house coal market is affected by seasonal influences, but the demand is good considering the time of the year. The coke market has undergone no material change.

THE LATE MR. P. H. STEVENS.—It is with regret that we record the death of Mr. Percy Herbert Stevens, which occurred in a Northampton nursing home on July 8. He was a director of the Express Lift Company, Limited, one of the associated companies of the General Electric Company, Limited. Mr. Stevens had been associated with the Express Lift Company and its amalgamated company, Messrs. Smith, Major and Stevens, Limited, for nearly 50 years. He was also a director of the Law Land Company.

THE LATE MR. FRANK MOORE.—One of the pioneers of precision-tool manufacture in this country, Mr. Frank Moore, managing director of Messrs. Moore and Wright, Limited, Sheffield, has died at the age of 66. Mainly by his own exertions he succeeded in establishing, in Sheffield, the manufacture of precision tools which had previously been a monopoly of firms in the United States. Commencing business in 1905, he travelled extensively on the Continent to obtain orders. In 1935 he was awarded a Grade A certificate, by the National Physical Laboratory, for a master square, having a blade 20¼ in. in length, which was then described as the most accurate in existence.

STATIONARY ENGINE PERFORMANCE IN MOTOR LORRY.—An interesting transference of one of their 10/11-h.p. two-cylinder oil engines is reported by Messrs. Ruston and Hornsby, Limited, Lincoln. The engine was supplied for driving well-boring gear near Rangoon, and functioned satisfactorily for over two years, at the end of which time it was no longer required. The owner then fitted it to a 2-ton Albion lorry chassis, which is now in regular employment. A typical performance of the lorry is that of a trip of 1,012 miles, made in 80 running hours. The total consumption on this trip was 42 gallons of light Diesel oil and 1 gallon of lubricating oil, the actual running cost working out to 3·66 pies per mile, *i.e.*, a little over one farthing at current exchange. On the outward trip, viz., 506 miles, the load was 1¼ tons. The greater part of this trip was made on a good road surface on which a maximum speed of 22 m.h.p. was achieved. The remainder of the route was little more than a very bad cart track on which only 2 m.h.p. to 3 m.p.h. could be maintained without taking undue risks. The return journey was made with a load of 1 ton. With a lighter load on a good road a speed of 30 m.p.h. can be obtained without overloading the engine. The original piston rings, supplied in July, 1938, are still in place, and no new parts have as yet been required. A circulating-water pump and equipment, however, have been added.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The iron and steel works are still actively employed and existing contracts will absorb the bulk of the output for the third quarter of the year, but pressure for delivery of most commodities has eased considerably and the congestion of orders at local works has been greatly relieved. The distribution of most descriptions of material is on a scale that deals satisfactorily with the actual needs of customers with priority delivery claims, and usual buyers are hoping for the early release of a larger tonnage for general commercial undertakings. Producers are steadily overtaking their commitments and the position now justifies a reduction in the deliveries of several overseas products.

Cleveland Iron Trade.—Foundry owners, although using exceptionally large quantities of scrap, are finding it hard to make increased demands for pig iron to cover the expanding needs of the plants in operation. No improvement in the supply of local foundry iron can be reported but other producing areas are keeping pace with the growing demands. Most of the iron passing into use at North East Coast foundries is from the Midlands. Firms using special qualities of iron are receiving ample supplies from several sources. It is reported that merchants now have control of rather more tonnage than hitherto, but would be glad to handle larger parcels. The fixed prices of Cleveland pig are based on No. 3 quality at 128*s.* delivered in the Middlesbrough district.

Basic Iron.—Makers of basic iron continue to retain the whole of their heavy output for use at the adjacent steelworks. Stocks are light but are increasing slightly.

Hematite.—The demand for hematite is diminishing as the use of substitute iron increases, but deliveries are still inadequate and distribution is on a restricted scale. The prospects of a material increase in the moderate production are still remote and market transactions are confined within narrow limits; second hands have control of but little tonnage. The stabilised values are at the level of No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England areas.

Foreign Ore.—There is no new feature in the foreign ore trade. Various obstacles are impeding the supply of descriptions needed for the manufacture of hematite, but the imports of most other kinds is quite equal to current requirements now that extensive use is being made of native ironstone.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is on a very moderate scale. The supply is still plentiful but sellers are not inclined to book extensive orders until they have reduced their delivery obligations and local users have covered their requirements as far ahead as they consider to be necessary.

Manufactured Iron and Steel.—Stocks of semi-finished iron and steel at the re-rolling mills are large, but contract deliveries are still readily accepted. Manufacturers of finished products are busily employed and outputs are passing promptly into use, but there is a considerable reduction in the orders placed recently for some descriptions of steel. There is, however, an unabated demand for ship, tank and boiler plates, sheets and special alloy steels.

Scrap.—Heavy-steel and cast-iron scrap are still in great demand, but light cast iron, steel turnings and cast-iron borings are not so urgently required.

FORGE SHOP AT KEMBLA WORKS, AUSTRALIA.—Extensions to the forge shop at the Kembla Works of Messrs. Australian Iron and Steel, Limited, have recently been completed. Six reheating furnaces of various types, all fired by coke-oven gas, are now available and a 2,000-ton hydraulic press has been installed. Ingots up to 36 tons in weight can now be forged in this shop.

DESTINATION CONTROL CERTIFICATES FOR EXPORTERS.—The Ministry of Economic Warfare has announced that a new facility has been provided for exporters in the United Kingdom, in the form of a document called a Destination Control Certificate. Goods exported from this country are sometimes trans-shipped or unloaded at ports in other parts of the British Empire, or in Egypt, Portugal or the Persian Gulf, *en route* for a neutral destination for which the export from the United Kingdom is permitted by H.M. Customs. In order to avoid any unnecessary delay in granting transit facilities for the goods at such ports, it is desirable that an official document showing the ultimate destination of each consignment should accompany the goods for presentation to the authorities in the port of discharge. Such a document, known as a "Destination Control Certificate," can now be obtained on application to H.M. Customs in a United Kingdom port. Exporters are advised to ask for this certificate whenever it would appear to be necessary.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

ROYAL METEOROLOGICAL SOCIETY.—Saturday, July 19, 2.30 p.m., 49, Cromwell-road, South Kensington, S.W.7. Joint Meeting with the *London and Home Counties Branch* of THE INSTITUTE OF PHYSICS. General Discussion on "Thunderstorm Problems." (i) "The Physics of Lightning," by Dr. T. E. Allibone. (ii) "The Distribution of Electricity in Thunderclouds," by Dr. G. D. Robinson. (iii) "The Air Currents in a Lightning Storm," by Mr. J. F. Shipley. (iv) "Lightning and Atmospherics," by Mr. F. E. Lutkin.

IRON AND STEEL INSTITUTE.—Saturday, July 19, 3.30 p.m., The Station Hotel, Dudley. Joint Meeting with THE STAFFORDSHIRE IRON AND STEEL INSTITUTE. (i) "Non-Metallic Inclusions in Steel: Quantitative Evaluation.—Part I," by Dr. W. H. Hatfield and Mr. G. W. Giles. (ii) N.P.L. Report: "Intercrystalline Cracking in Boiler Plates," to be presented by Dr. C. H. Desch. (To be preceded by a luncheon at 1 p.m.)

PHYSICAL SOCIETY.—Friday, July 25, The Science Museum, Exhibition-road, South Kensington, S.W.7. 4.40 p.m., Annual General Meeting. (i) Presentation of Report of the Council. (ii) Election of Officers and Council for 1941-42. 5 p.m. Science Meeting. The First Charles Chree Address on "(i) Chree and His Work on Geomagnetism; (ii) Geomagnetic Time Relationships; (iii) The Future of World Magnetic Surveying," by Professor Sydney Chapman.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—It was thought during recent weeks that there would be another increase in steel prices at the beginning of July, but no change was made and quotations remain without alteration for the time being. All the Scottish works continue to be busy and the general demand is steady; all the usual consumers are pressing for deliveries. The demand for special high-grade steel has increased to a considerable extent and the demand is not only likely to continue, but will probably increase still further. In the black steel-sheet trade the position is somewhat stronger, as the consumption of both plain and galvanised sheets has been growing and orders for a large tonnage has been placed recently. Raw materials are in fairly good supply, but steel scrap is not very plentiful. The current prices are as follow:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade the conditions show little change; fair supplies of raw materials have been coming in. The re-rollers of steel bars, although still fairly busy, are able to give quick delivery for new orders. They are all well covered with semies at present, and it is probable that imports will be reduced. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the demand is still very heavy and the large output from the blast-furnaces is rapidly taken up. There is steady pressure for hematite and basic iron for essential purposes, and business in foundry grades is better. The necessary raw materials have been coming to hand in satisfactory quantities and ample stocks are now held. Prices show no change and are as follow:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

CONCENTRATION OF TIN-PLATE INDUSTRY.—The Minister of Supply has appointed a committee to consider and report on the application, to the tin-plate industry, of the policy of concentration of industry. The chairman is Lord Essendon, J.P., and the other members are Captain H. Leighton Davies, C.B.E., J.P. (chairman of the Tin-Plate Conference); Mr. J. E. James (Messrs. Richard Thomas and Company, Limited); Major Llewellyn David (Messrs. D. R. David and Company); Mr. John Brown (Iron and Steel Trades Confederation); Mr. P. Owen (Transport and General Workers' Union); and Mr. R. G. Lewis (National Union of General and Municipal Workers). Mr. J. C. Carr, Raw Materials Department, Ministry of Supply, The Castle, Warwick, will act as secretary to the committee.

THE BRITISH "VALENTINE" INFANTRY TANK.

FIG. 1. TANKS CROSSING OPEN GROUND.

FIG. 2. TANK CLIMBING BANK.

FIG. 3. TANKS LINED UP ON ROAD.

BRITISH AND RUSSIAN INFANTRY TANKS.

SOME particulars have now been revealed of the latest type of British infantry tank, formerly known as the Mark III, but now officially designated as the "Valentine." Figs. 1 to 3, on this page, and Figs. 4 and 5 on Plate I, show various views of the Valentine type, which weighs 16 tons and is manned by a crew of three. Infantry tanks in general are more heavily protected, but less speedy, than the "cruiser" tanks used by the mechanised cavalry regiments, some description of which appeared on page 581 of our 149th volume (1940); but it is stated that the Valentine has a road speed in excess of 15 miles an hour, and, for the weight of guns and armour which it carries, has proved to be faster than was expected. Its manœuvrability and cross-country riding qualities are of a high order. The turret mounts a Besa gun, at the side of which is a 2-pounder, stated to be capable of penetrating the armour of any German tank that the British forces have yet encountered.

For comparison, we append in Figs. 6 and 7, on Plate I, views of the Russian type of infantry tank now reported to be performing such good service in stemming the German attacks. In general appearance, it will be seen, there is a distinct similarity, although the Russian design gives the impression of being rather lighter than the British. Both drive on the rear sprockets as is customary and, indeed, almost inevitable, but the weight of the Russian tank is supported on only four track wheels on each side, as against six, of smaller diameter, and arranged in groups of three, in the British. The track itself, in the Russian design, is clearly of a lighter construction and seems to carry only one row of widely spaced driving teeth, presumably passing between twin tyres on the carrying wheels. Reference to the illustrations of the Valentine will show that the method of driving and guiding the track is by a double row of teeth; an arrangement which would appear to have superior advantages when traversing soft ground or the slope of a hill, and to offer the probability of smoother progress over rough ground such as that illustrated in Fig. 1. It must be remembered, however, that the Russian tank has been designed primarily to operate over country of a more uniform kind and greater extent than is likely to apply to the designs of any other nation, which must be more definitely of a general-purpose character. Tanks, like warships, must represent a compromise, and the dominant factors can seldom be the same in different armies.

(To face page 50.)

BRITISH AND RUSSIAN INFANTRY TANKS.

(For Description, see Page 50).

FIG. 4. VIEW SHOWING BROADSIDE AND REAR OF VALENTINE TANK.

FIG. 5 FRONT VIEW OF VALENTINE TANK.

FIG. 6. RUSSIAN INFANTRY TANKS CROSSING DRY DITCH.

FIG. 7. RUSSIAN INFANTRY TANK ON SOFT GROUND.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, JULY 18, 1941.

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WAR PRODUCTION.

THE announcement by the Prime Minister in the House of Commons on Tuesday, that a third day is to be allotted to a resumed discussion of the problems of munitions production, to some extent restricts the comments that otherwise might be made on the criticisms so freely expressed in the House on July 9 and 10. So far as those criticisms consisted of specific allegations or complaints, Mr. Churchill stated, they would be investigated by the Departments concerned, and he proposed to make a statement himself on the general position. Meanwhile, he regretted the trend of the debate, which might well convey to other nations, friendly and otherwise, an unfavourable impression of the state of war production in this country which was not in accordance with the facts. It was impossible for newspapers to report the debates at any length in present circumstances, and emphasis given to adverse comments was liable to distort the picture of the remarkable efforts of production which, in fact, had been achieved, especially during Sir Andrew Duncan's tenure of the office of Minister of Supply.

From many points of view, last week's debate on production must be regarded as disappointing. In part this was due, no doubt, to Parliamentary rules and the organisation of Parliamentary business, which obliged the Chairman (the House was in Committee) to rule out of order any references to labour supply because these could only be considered on the Ministry of Labour Vote. As many Members found, however, it is not easy to discuss production and the efficient employment of labour without introducing the subject of labour supply; which may be one reason why, at times, the debate appeared to be concentrated mainly on the alleged deficiencies of management, when the criticism was not being levelled even more directly against the deeper problems of policy in the organisation of war production. If all the complaints were individually examined, however, it would probably be found that in very few cases were the deficiencies due to causes arising directly in the works against which the complaint was made. In almost every instance there would prove to be outside influences involved, over which the persons concerned had little or no control, and that the situation complained of was actually the culmination of a series of shortcomings, most of them attributable to the abnormal conditions under which industry is now operating.

It is probable that very many of the deficiencies to which reference was made will be found, on examination of the facts, to be due to the primary difficulty, pointed out by Rear-Admiral Beamish, that the specially constructed factories began operations without the advantage of the team spirit and the team organisation that is found in any well-managed private concern. These are factors which cannot be created at short notice, nor can their growth be forced to any appreciable extent. The possibility of forcing them at all may well be doubted when the personnel consists so largely, as it must do in such circumstances as now exist, of men and women who are at best only semi-skilled in the work required of them, however expert they may have been in their former occupations. There is a side street in London which is well known as a rendezvous for temporarily unemployed dance-band musicians. An agent who has undertaken to provide a band for some evening function can go there in an afternoon, pick the instrumentalists he desires, almost at random, and rest assured that they will work together as a band, only five or six hours later; because the men are not only expert in their particular kinds of noise production, but are skilled in the art of working together. The organiser of a new munitions factory is in a much less happy position; his "lower deck" personnel probably number only a small proportion of really skilled men and his managerial and supervisory staff are likely to be little better, there being no longer any reserve of thoroughly experienced men in these grades upon which to draw. In the circumstances, the progress that has been made, and the success that has been achieved, often in the face of obstacles of which the general public and even most Members of Parliament know very little, is truly remarkable.

Nevertheless, there is sufficient substance in the complaints of inefficient working to justify a more detailed examination of the whole position: and the blame is by no means to be imputed solely or even mainly to the management of individual factories. The immense volume of "paper work" that spreads like a blight over everything in which governments take a hand wastes, in the aggregate, enough time and energy to account for a considerable proportion of the 25 per cent. by which, according to Sir John Wardlaw-Milne, actual output falls short of the figure that should be attainable. Not only is the flood of forms enormous in quantity, but it is rare to find a form of any significance which is reasonably clearly drafted and can be completed expeditiously without doubts regarding its intended meaning. There is not nearly enough co-ordination between the form-issuing divisions of the numerous Departments which now have the right to impose their demands upon industry, and there are far too many attempts to produce single forms which shall be applicable to a dozen branches of manufacturing activity that are only superficially allied. As a result, every executive official who has to complete such a form is compelled to study carefully a number of sections that do not concern his firm at all, but which must be studied carefully before he can be sure that they do not; and then he is quite likely to find that the questions which do concern him are couched in such terms as to be difficult to reconcile with the statistics available. Some of this complication may be inevitable, but much of it is palpably avoidable and should not be permitted to continue.

In the actual distribution of orders and of the material necessary for their execution, there have been lapses for which no blame could be attributed to the managements of the works affected; but their employees have not always the opportunity to learn the true circumstances and it is natural that, lacking such knowledge, they should feel and express some discontent. Such conditions are

eagerly seized upon by interested parties as reasons for giving the employees as a whole a direct and active share in the management; but that would not expedite the flow of either orders or material, and, from several points of view, might be definitely undesirable. The motives which have inspired some suggestions of this kind are patently such as to confirm the impression that some branches of organised labour, at any rate, are missing no opportunity to exploit the national emergency for their sectional interests, with a view to securing so firm a hold of industry in general that they will be able to dominate it when the present Government control is relaxed on the termination of hostilities. We do not believe that the majority of the men themselves, especially in the skilled trades, either desire such domination or are convinced that it would be to their permanent advantage; unfortunately, the most thoughtful are often the least vocal.

Whatever complaints may be reasonably made against the management of the new Government factories, there seems no real ground for condemning that of the privately owned establishments, where the average of efficiency is unquestionably high. Not only have these staffs had to cope with all the complexities of official control and interference, with its endless form-filling, but in very many cases they have played an important part in designing equipment for which the Ministries were ostensibly responsible and in extricating those same Ministries from difficulties which were largely of their own making. These private managements have never yet received the credit that is due for their most responsible share in transforming the munitions production programme into a working reality. Their hours are long, their reward relatively small, and their future is far from being assured. They have a better right than most to join in the recent protest by the Recorder of London, Sir Gerald Dodson, K.C., against the snobbish exclusiveness of the term "workers," and the extent to which it is now employed, even in official documents. The public memory is short, or it would not tolerate so easily this subtle infiltration of the "boss word" of the agitators of former years, who stressed it solely for the sake of its implication that those who were not "workers" were "drones."

Recriminations in Parliament or outside of it, we may expect to be assured, will serve no useful purpose; but, without necessarily subscribing to Sir John Wardlaw-Milne's estimate of 25 per cent. as the shortage of productive efficiency, it may be observed that others besides foreigners read the published reports of Parliamentary proceedings, and the realisation that so much dissatisfaction has been expressed may well go a long way towards correcting the reasons for it. There is much that might yet be done, however, to promote a still greater efficiency—by which is meant a better return for the time and energy and money expended. A few weeks ago, a trade-union spokesman was reported to have said, with much unction, that he had a list of some 9,000 rules and practices which had been relaxed or abandoned in order to aid the war effort, and which must be restored on the termination of hostilities. No doubt these relaxations have contributed materially in the aggregate; but the really important point is not how many rules have been relaxed, but how significant they were in practice, and how many, relatively more significant, still remain effectively in force. To what extent, for example, have the ship-repairing trades abandoned their various local rules which prevent ships' crews from doing overhauling work on board ships where members of these trades are engaged? Are there still any districts where welding of plate-work is uneconomic, although speedier, because of insistence that the same number of men must be engaged as would be required for hand riveting? For more than a year the Government has had full power to remove obstructions of this kind wherever they may be found, as well as to apply compulsion on the managerial side of industry. We agree with the Minister of Labour that, in principle, it is better to lead than to drive, but believe that a firmer handling of these problems would have been appreciated by a majority of those affected, and that it would have increased production materially.

SECTIONAL INTERESTS IN ENGINEERING INSTITUTIONS.

MENTION was made in the 1939-40 Report of the Council of the Institution of Electrical Engineers that consideration was being given to the question of setting up an Installation and Utilisation Section of the Institution on the lines of the existing Wireless; Meter and Instrument; and Transmission Sections. The matter was not proceeded with at that time owing to the conditions prevailing, but it has now been announced that the section, which will be known as the Installations Section, is to be formed forthwith. It is stated that, notwithstanding the difficulties attending a step of this kind in wartime, circumstances have arisen which indicate that the formation of the section should no longer be postponed; in the post war reconstruction, the field of work to be covered by the section will attain great importance and its proceedings will have a useful bearing on many of the problems which will arise.

The scope of the new section will embrace all matters relating to the "study, design, manufacture, construction, installation, maintenance, operation and employment of equipment and apparatus used in electrical installations inside and outside buildings, including those for lighting, heating, ventilating and domestic purposes, and for general industrial, agricultural, mining and marine applications, but excluding matters relating to heavy engineering." The particular subjects which come within the spheres of the Wireless, Meter and Instrument, and Transmission Sections will be excluded from the programme of the Installations Section. It is obvious that cases may arise, or papers may be put forward, which might reasonably be ruled to fall within the ambit of, say, both the Instrument and Installations Sections, but their fair allotment is not likely to present serious difficulties to the sectional committees concerned, and in any case the Installations Section will not be a closed corporation and all members can attend any meetings arranged by it.

The Institution of Electrical Engineers was the first of the great engineering institutions to constitute special sections concerned with distinct branches of the field covered by the organisation as a whole. The procedure has since been followed by others, notably the Institution of Mechanical Engineers. This latter body terms its special sections "Groups," but in aim and constitution they do not appear to differ materially from the "Sections" of the Institution of Electrical Engineers. In range, the begetter of the system has been passed by its emulator and as compared with the four sections, including the new one, of the "Electricals," the "Mechanicals" have five groups either in being or embryo. The Education, Internal Combustion Engine, and Steam Groups are in active existence and have held various meetings; those concerned with Hydraulics and Manufacture have not advanced greatly beyond the preliminary stage. Present conditions are, no doubt, a sufficient explanation.

The formation of these specialist sections inside the broad field of an engineering institution is clearly of value, and the ordinary member who feels that his qualifications do not altogether fit any of them suffers no detriment. The sections are open to anyone with suitable qualifications, but have no special privilege beyond that of electing a committee, and, from the point of view of the institution as a whole, perform the important service of ensuring that specialist interests shall not be overlooked by a Council on which, at any particular time, they may chance not to be represented. The specialised committee, moreover, is more likely than a general Council to know which particular aspects of its own branch of work should be ventilated at meetings, and who are the authorities in its field. It is consequently likely to ensure that the papers it fathers shall be of greatest value, not only to members of the section, but to the institution as a whole.

The genesis of this group system is of interest. It was not the outcome of a conscious realisation inside the Institution of Electrical Engineers that special interests might usefully be fostered by special organisations. That realisation took place outside and was followed by the creation of independent bodies concerning themselves with wireless matters. These latter clearly fall within the Institution's sphere of interest, and, apart from the fact that the growth of what may fairly be described as outside competitive societies would have tended to affect the financial and numerical strength of the parent body, it was clearly desirable that the technical representation of this important and growing sphere of work should not be shared among a series of independent bodies, some, perhaps, of unimportant status. These considerations led to the formation of the Wireless Section, and it may be taken as certain that those whose activities might have been exercised for the benefit of an independent self-contained wireless society now employ them more usefully and effectively under the ægis of what may almost be described as the "official" electrical association.

Circumstances not greatly different led to the formation of the Transmission Section. A society known as the Overhead Lines Association came into existence, and displayed much activity. Although this country is now covered with overhead lines, it is not many years since they were considered to be unsuitable to the conditions of British practice. Although not forbidden, they were not encouraged by the Board of Trade. Under these conditions the Institution may possibly have given the subject less attention than it deserved. Certainly, a body of engineers operating systems which included overhead lines thought so and, as a consequence, formed themselves into the Overhead Lines Association. As in the case of wireless matters, the Institution realised that this outside activity was undesirable, and, accordingly, it inaugurated the Transmission Section and brought the activities of the Association, which was mainly constituted by its own members, within the fold. It has long been desirable that, as far as possible, the expression of the interests of engineers as a whole should be co-ordinated, so that they may carry full weight in public matters. This desirability is likely to be increased in the future. Regulations and controls every day become wider and more complicated, and evidence is not lacking that much of the present regimentation may be carried over into peace time. The organisation of sectional interests within the framework of a main body is a step towards this co-ordination, and the proceedings of the two great bodies with which we have been dealing cannot but lead to speculation on the desirability of carrying the process farther. In the mechanical field, in particular, there are two important institutions the activities of which fall so definitely within the sphere of the Institution of Mechanical Engineers that that body has two Groups, dealing, respectively, with internal-combustion engines and manufacture, which cover practically identical ranges.

We hesitate to make the bold suggestion that the Institution of Automobile Engineers and the Institution of Production Engineers should be absorbed by, and become groups of, the Institution of Mechanical Engineers. The two former bodies could doubtless adduce strong arguments against such a proposal; and the difficulties attending the amalgamation of important institutions, even those with close interests, is illustrated by the years of negotiation between the Iron and Steel Institute and the Institute of Metals. These two metallurgical bodies, however, although they have not become one, have introduced a system of close interworking, with a common library and a composite subscription carrying membership of both. Some such association of interests and activities between the Mechanical, Automobile and Production Engineers would represent important steps towards a unity which is desirable. Evidence of existing co-operation between the Institution of Mechanical Engineers and the Institution of Production Engineers has been provided by the joint publication of *Acceptance Tests for Machine Tools*, and it would appear that matters might well be carried farther. No doubt many members of the Mechanicals, closely interested in this matter, are not members of the Production Engineers, but the fact that they are justified in expecting the parent body to concern itself more directly with a subject, which it has dealt with in a rather perfunctory manner in the past, does not dispose of the disadvantages of divided effort and unco-ordinated activities.

NOTES.

THE INSTITUTE OF BRITISH FOUNDRYMEN.

THE 38th annual general meeting of the Institute of British Foundrymen was held on Saturday last, July 12, at the Midland Hotel, Manchester, under the presidency of Major R. Miles, M.Eng., managing director of Messrs. Head, Wrightson and Company, Limited, Thornaby-on-Tees. In addition to Major Miles's presidential address, four papers were delivered, these being "American Synthetic Sand Practice," by Mr. Norman J. Dunbeck, vice-president of Messrs. Eastern Clay Products, Incorporated, Eifort, Ohio—a paper presented under the exchange arrangement between the Institute and the American Foundrymen's Association; "Mould and Core Washes," by Mr. William Y. Buchanan; "Moulding Steam-Valve Lids for Marine Service," by Mr. Frank Hudson; and "British National Specifications for Cast Iron," by Mr. J. G. Pearce, M.Sc. Major Miles devoted the greater part of his address to a consideration of the conditions that may be expected to obtain after the war, with special reference to the foundry industry. The problem of changing over from war production to peace production, he observed, was of equal magnitude with that of initiating and developing the full war production, and its speed was likely to be no greater; it was almost inevitable, therefore, that control would persist for some years after the war. He regarded this as desirable. Apart from war conditions, amalgamations into big units and co-operation among smaller units were growing tendencies. He was not convinced that schemes of nationalisation and socialisation of all industries had reached a stage of technique where it could be safely said that they would be accompanied by a higher standard of living; but in large well-established industries such as founding there would be "no more *laissez-faire*, even though the devil may still take the hindmost." The characteristic feature of the foundry trade—namely, the existence of a comparatively large number of small privately-owned foundries—would make any national plan of production very difficult. The question of the size of a producing unit could be determined simply on economic grounds; if the small foundry could deliver better and cheaper castings than the large one. Such castings would be made in small foundries. The full benefit of mechanised systems of production, in releasing man-power, had not yet been reaped. The working hours in the week had been reduced, and further man-power was needed to produce the mechanical aids and also in the much more elaborate system of distribution now necessary; but he visualised the possibility, in the present generation, of reducing the working week still further, of lowering the age of retirement, and of raising the school-leaving age. This vision did not relate to the immediate post-war period, when a starved world would probably be able to accommodate and consume goods that would require long hours to produce, but to a longer and more general trend, when interchange of commodities might again reach comparative stability. This would demand, however, some degree of training to make proper use of increased leisure. In this country, the standard of education and the appreciation of the good things of life was certainly higher than in many other populous countries; but that high standard carried with it the obligation that it had to be earned. To continue that higher standard it was necessary that scientific research and development should be vigorously and successfully pursued, and that steps should be taken to ensure that a practical realisation of exchangeable value accrued from such efforts.

INSTITUTION SUBSCRIPTIONS AND INCOME TAX.

A case of interest to many engineers was dealt with in the High Court of Justice on July 9. The Crown appealed against a decision of the Income Tax Commissioners that a sum of 2*l.*, paid by Mr. D. C. Graham as part of his subscription as a member of the Institution of Civil Engineers, might be deducted in determining his income under Schedule E, as it was spent wholly, exclusively and necessarily in the performance of his duties. Mr. Graham retired in July, 1939, and contended that the portion of his Institution subscription attributable to the period from April 6 to July 6, 1939, could properly be counted as expenses. This contention was agreed to by the Income Tax Commissioners, but was contested by the Crown. It was established at the hearing of the case that a Divisional Engineer to the London County Council, a position which Mr. Graham held, was required to be a corporate member of the Institution of Civil Engineers, or to hold other approved qualifications, and that there was no case of record of an engineer having relinquished membership of the Institution during his period of service. The duties of the office also included statutory functions which could only be properly discharged by a person holding recognised professional qualifications. In its appeal the Crown contended that it was not sufficient to show that the payment of the subscription was necessarily incurred in order to secure, retain or obtain preferment in office, and that the sum of 2*l.* was not spent by Mr. Graham wholly, exclusively and necessarily in the performance of his duties. The contention of the Crown was sustained by the Court, but Mr. Justice Macnaghten, *in* delivering judgment, said that he allowed the appeal reluctantly.

THE WELSH HIGHLAND RAILWAY.

Yet another of the narrow-gauge railways of the British Isles is now in process of demolition. The Welsh Highland Railway, which is now being dismantled by Messrs. George Cohen, Sons and Company, Limited, connected Dinas Junction, in Carnarvonshire, with the formerly flourishing port of Portmadoc, and was constructed to the curious gauge of 1 ft. 11½ in. The total length is about 28 miles. Originally opened as the North Wales Narrow Gauge Railway in 1875, it extended only from Dinas Junction to South Snowdon; but an extension was made in 1923 to Portmadoc, to connect with the Festiniog Railway of the same gauge, the name being then changed to the Welsh Highland Railway. In 1934, the line was leased to the Festiniog Railway, but, at the end of 1936, it was closed to all traffic. The track is single and consists of spiked rails, 36 lb. to 41 lb. per yard, the maximum gradient being 1 in 35. The locomotive stock numbered two only, namely, a 2-6-2 tank engine built in 1906 by the Hunslet Engine Company, Leeds, and a Baldwin 4-6-0 tank, built in 1917. The latter engine was employed by the R.O.D. during the last war. The nameplates, number plates, and maker's number plates of the engines are to be preserved in the Railway Museum at York. The other stock comprised ten bogie coaches and 104 wagons. The main line was relaid as recently as 1922, and it is expected that about 1,200 of the rails recovered will still be serviceable.

THE PROFESSIONAL CLASSES AID COUNCIL.

The report of the Professional Classes Aid Council for the year ended April 30, 1941, shows that expenditure on relief increased by 1,551*l.*, including 1,441*l.* spent on cases of war distress, and that the total of contribution diminished by 1,236*l.*, resulting in a deficit of 889*l.* on the year's working. During the year, 333 families were given financial assistance, and, in addition, 212 cases were advised of other sources of help to which they might apply. Only two applications were adjudged to be "unsatisfactory"—the lowest figure in the records of the Council, which has now been in active existence for nearly 27 years. In October, 1940, the office of the Council was transferred to new quarters at 20, Campden Hill-square, London, W.8, which have been leased from the executors of the late chairman, Sir John Seymour-Lloyd. The house in which they are situated is part of the residue of the estate bequeathed by him to the Council to enable pensions to be provided to suitable applicants from the professional classes. The subscription income for the year under review amounted to 3,438*l.*, and donations to 4,938*l.* Income from investments, from the special funds administered by the Council, and from various minor sources, brought the total income for the year to some 14,746*l.* The total amount expended on relief, including the war cases mentioned above, was 13,054*l.*; and the net expenses of administration amounted to 1,438*l.*, not including the cost of appeals and publicity, which totalled 992*l.* In pursuance of the general policy of the Council, the grants made were mainly either educational or designed in other ways to enable the recipients to become self-supporting, 5,606*l.* being expended on educational fees and maintenance during education, and 2,067*l.* on training fees and maintenance, the latter item representing an increase of 671*l.* over the figure for the previous year. The professions and callings represented, either by members or their dependants, among those who sought the guidance or assistance of the Council during the year included accountants, architects and surveyors, lawyers, civil servants, engineers, scientists and research workers, university professors, and officers of the Navy, Army, Air Force and the Mercantile Marine. In addition to disbursing their own funds, the Council act as almoners on behalf of other societies and of individuals who may wish to remain anonymous, and, during the period reviewed, distributed 3,737*l.* in this way. The Council record with regret the death, *inter alia*, of Mr. E. W. Monkhouse, M.Inst.C.E., representative of the Benevolent Fund of the Institution of Civil Engineers from 1921 and for some time honorary treasurer and a member of the Executive Committee. He has been succeeded on the Council by Mr. E. Graham Clark, B.Sc.

SHIPBUILDING IN THE UNITED STATES.

Some informative statistics concerning the progress of merchant-ship building in the United States, apart from the standard-ship programme in hand for British account, are contained in the June *Bulletin* of the American Bureau of Shipping. The number of vessels of 1,000 tons or over under construction or on order on June 1, 1941, and intended to receive American Bureau of Shipping classification, was 826, amounting in all to some 5,350,000 tons gross. Of these, 116 vessels of 788,545 tons, were ordered during May. The total includes a number of barges and small craft, but these do not greatly affect the aggregate tonnage, as 690 ships, of 5,240,000 tons, are listed as "sea-going." The rapid expansion of the American shipbuilding effort is shown by the fact that, exactly twelve months earlier, the total was only 295 vessels of all kinds, aggregating 1,516,000 tons. In addition to the 826 ships mentioned above, there were in hand or on order in United States shipyards on June 1, 1941, a further 64 ships, including the 60 ordered by the British Purchasing Commission from the new yards at Portland, Maine, and Richmond, California. The grand total, therefore, is 890 ships, of 5,794,000 tons, of which 805, of 5,752,000 tons, are self-propelled by machinery totalling some 3,440,000 h.p. The details given of the types of propelling machinery are of particular interest. Of the 805 power-driven ships, 635 are to be propelled by steam engines, either turbine or reciprocating; 63, all tankers, are to have turbo-electric machinery; 106 are to be Diesel-driven; and only one, a small ferryboat for the General Motors Sales Corporation, is to have Diesel-electric machinery. As this installation is of 950 h.p. only, it may be said that Diesel-electric propulsion finds no real place in the American shipbuilding programme. Three of the 63 turbo-electric tankers are 11,400-ton vessels, building by the Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, to the order of the Atlantic Refining Company, and will have machinery of 5,000 h.p. The other 60 ships form part of the emergency programme of the Maritime Commission and are of approximately 10,000 tons each, with machinery of 5,400 h.p.; none of them had been laid down at the beginning of June. This emergency programme consisted, at that date, of 384 ships, 312 of which were to have single-screw triple-expansion reciprocating engines; doubtless to enable firms not equipped for turbine or Diesel work to assist in constructing the machinery, the usual builders of marine propelling engines being already fully occupied with naval work and with the geared turbines and Diesel engines which were standardised for the original Maritime Commission programme of 198 ships. Eighty-nine of these ships have now been delivered. As the details of the combined "pre-war" and emergency programmes of the Maritime Commission develop, it is rather striking to notice the comparative decline of the Diesel engine. Of the grand total of 582 ships, only 54 are to be Diesel-propelled, their aggregate horse-power amounting to only 322,500 out of a total of about 2,710,000 h.p.

THE DETERMINATION OF WATER VAPOUR IN FLUE AND EXHAUST GASES.

By R. H. PARSONS, M.I.Mech.E.

ACCORDING to *The Dictionary of Applied Physics*, the methods available for determining the amount of water vapour in air or gas are divided into five classes, based upon (*a*) the observation of the dew-point; (*b*) the readings of wet-bulb and dry-bulb thermometers; (*c*) the measurement of the actual mass of water vapour in a given volume; (*d*) the change of pressure when the water vapour is removed by absorption; and (*e*) the use of hygroscopic substances. For work outside a laboratory, the most practical of these are the methods comprised under headings (*b*) and (*c*), both of which have wide applications in connection with air-conditioning and similar processes. Neither of them, unfortunately, can be used conveniently, if at all, except when the air or gas is at a very moderate temperature, and, so far as the writer is aware, there is no existing method of measuring the moisture content of hot flue or exhaust gases which does not require either skill or apparatus unavailable in ordinary engineering work. The consequence is that the heat carried away by the water vapour in such gases is ignored except when special tests are in progress, and even then the moisture content can only be arrived at indirectly by calculations based on an ultimate chemical analysis of the fuel.

It seems worth while, therefore, to draw attention to another way of determining the humidity of gas or air at fairly high temperatures, which depends on a principle different from any of those enumerated above. By making use of the ordinary gas laws and the known properties of water vapour as given in steam tables, the quantities of moisture present can easily be found. The only apparatus required is very simple. All that is necessary is an air-tight container for the sample of gas, provided with a thermometer for measuring the temperature and an aneroid barometer, or equivalent device, for measuring the pressure of the sample. The size of the container is of no importance; neither need its capacity be known, as this does not affect the matter. The apparatus may comprise a flanged pipe with end covers into which pipe connections with stop cocks are fitted, for the entrance and exit of the gas. A thermometer and Bourdon gauge are provided to measure the temperature and pressure, respectively, of the gas. To make a test, gas is first caused to flow through the container until a steady temperature is reached. Both stop-cocks are then closed and the readings of the thermometer and gauge are noted. The gas in the chamber is then cooled, or allowed to cool, down to some temperature that is known to be below its dew-point, after which the thermometer and the pressure gauge are again read. From the figures thus secured, it is easy to compute the humidity of the gas in its original condition.

The theory of the process is as follows: The total pressure P, of the charge at its initial temperature T, is the sum of the partial pressures of the incondensible gases and the water vapour, respectively, or

$$P = P_g + P_w \quad . \quad . \quad . \quad (1)$$

After the charge has been cooled down to any lower temperature t, we have the similar relationship:

$$p = p_g + p_w \quad . \quad . \quad . \quad (2)$$

Provided that the temperature t is below the dew point, the partial pressure p_w can be found from any steam table, because it must be the same as the pressure of saturated steam at the temperature in question. The value of p_g, the partial pressure of the incondensible gases at the lower temperature, can therefore be obtained from equation (2), because the value of p is known from observation. Furthermore, as, by Dalton's Law, each component of a mixture of gases exerts its own pressure independently of that of the other components, and since this pressure is proportional to the absolute temperature, we have—

$$P_g = p_g \times \frac{T + 460}{t + 460} \quad . \quad . \quad (3)$$

and it follows, therefore, from the three equations given, that—

$$P_w = P - (p - p_w) \times \frac{T + 460}{t + 460} \quad . \quad (4)$$

From equation (4) we can calculate P_w, the partial pressure of the water vapour in the original sample, since all the variables on the right hand side of the equation are known.

It is, of course, essential to the method that the lower temperature t shall be below the (unknown) dew-point of the sample of gas. When dealing with flue gases this requirement presents no difficulty. With any ordinary coal it will be quite sufficient to cool the sample of flue gas down to 70° F. to ensure that the dew-point has been passed, even if the coal is in a dry condition when fired and is burnt with considerably more than the usual amount of excess air. When moisture is present in the fuel, or the gases are derived from the combustion of oil either in a furnace or in the cylinder of an internal-combustion engine, a final temperature of 70° F. is still further on the safe side. Certainty that the dew-point has been passed can be obtained by observing that, at the lower temperature t, the pressure in the container is less than $P \times \frac{t + 460}{T + 460}$, as it should be.

As an example of the application of the method, it will be assumed that flue gases are being discharged at 300° F. with a CO_2 content of 13 per cent., and that it is required to find the loss due to the water vapour they contain. Let a sample of the gases, which may for convenience be subjected to a preliminary cooling, be drawn into the container, filling it at a pressure of, say, 29·6 in. Hg., abs., and a temperature of, say, 200 deg. F. The stop-cocks having been closed, the gases are cooled down to 70 deg. F., when it is noted that the absolute pressure has fallen to, say, 23·0 in. Hg. Since the pressure of saturated steam at 70 deg. F. is 0·74 in. Hg., we have, from equation (4):

$$P_w = 29{\cdot}6 - (23{\cdot}0 - 0{\cdot}74) \times \frac{660}{530}$$

$$= 1{\cdot}88 \text{ in. Hg.}$$

Since the pressure of saturated water vapour is 23·52 in. Hg. at 200 deg. F., the humidity of the gases at this temperature, expressed in the ordinary way, was $\frac{1{\cdot}88}{23{\cdot}52}$, or 8·0 per cent., while the proportion of the whole volume that was occupied by water vapour was $\frac{1{\cdot}88 \times 100}{29{\cdot}6}$, or 6·35 per cent. Moreover, since the specific volume of vapour at 1·88 in. Hg. and 200 deg. F. is 425·5 cub. ft. per lb., the original weight of water in the gases must have been $\frac{6{\cdot}35}{425{\cdot}5 \times 100} = 0{\cdot}00015$ lb. per cub. ft.

The heat carried away by the moisture in the flue gases may now be found. Taking the proportion of CO_2 in the dry flue gases to be 13 per cent. as stipulated, the proportion in the wet gases will be $\frac{13 \times (100 - 6{\cdot}35)}{100} = 12{\cdot}17$ per cent. We have, therefore, 6·35 cub. ft. of moisture associated with every 12·17 cub. ft. of CO_2. Taking the molecular weights of CO_2 and H_2O as 44 and 18, respectively, there will be 114·3 lb. of water to every 535·5 lb. of CO_2, and since this weight of CO_2 contains $\frac{535{\cdot}5 \times 12}{44}$, or 146 lb. of carbon, we have, for every pound of carbon burnt in the furnace $\frac{114{\cdot}3}{146} = 0{\cdot}78$ lb. of water vapour going up the chimney.

It is thus a simple matter to compute the losses due to water vapour in the flue gases without any knowledge of the moisture or the hydrogen content of the fuel. The object of the article is, however, primarily to call attention to a method of hygrometry which seems to have been overlooked by writers on the subject. It is not suggested that it should supplant the wet and dry bulb thermometers, or other recognised method of determining humidity when such means are practicable, but it appears to have a field of usefulness in certain classes of work for which no simple method has been previously available.

LETTER TO THE EDITOR.

A THEORY OF THE KADENACY SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article published in your issue of June 13, on page 463, Dr. E. W. Geyer put forward a theory of the Kadenacy system. I should be grateful if you would allow me to comment on his treatment of the problem. The theory, which is based on the striking of an energy balance at the instant when the pressure in the vessel has fallen to atmospheric, appears to be open to criticism owing to the treatment of one of the kinetic energy items. Dr. Geyer states that, to a first approximation, the kinetic energy of the gas which has left the vessel up to the instant of pressure equalisation is $\frac{W_2 V_2^2}{2g}$, where W_2 is the weight of the escaped gas and V_2 is the velocity in the port at this instant. I suggest, however, that this statement is incorrect and that the total kinetic energy of the escaped gas will, in fact, considerably exceed the value assumed by Dr. Geyer, since consideration shows that the velocity of the emergent gases will vary during the discharge and will, in general, be higher during the interval prior to the instant of pressure equalisation than at the instant itself. This has indeed been demonstrated by the sound and logical arguments advanced by Dr. Giffen in an article published in your issues of August 16 and 23 and September 6, 1940, which, as your footnote indicates, Dr. Geyer had no opportunity of seeing before his own article was written.

This under-estimation of the kinetic energy of the escaped gases may possibly be responsible for the appreciable discrepancy between calculated and experimental results shown in Fig. 3 of Dr. Geyer's article, and I suggest that its effect is to make the results obtained by this method of calculation of questionable value. It is also worthy of note that the treatment adopted by Dr. Geyer is confined to a determination of the maximum value of the depression produced. Since the chief interest in the problem lies in the scavenge effect which can be produced in an actual engine, it appears that no treatment can be satisfactory unless it allows not only the magnitude of the depression, but also the duration and the instant of its occurrence to be obtained. It is also interesting to note that neither of the theories referred to above indicates the existence of the ultra-high velocities to which reference has been made by supporters of the Kadenacy claims nor throws any light on the mystical and unexplained term "ballistic discharge."

Your faithfully,

F. K. BANNISTER.

The University, Birmingham.
July 5, 1941.

OBITUARY.

SIR KEITH ELPHINSTONE, K.B.E.

WE note with regret the death, on July 6, of Sir Keith Elphinstone, chairman of Messrs. Elliott Brothers (London), Limited, Lewisham, S.E.13. George Keith Buller Elphinstone was born in Edinburgh in 1865 and was educated at Charterhouse. He served his apprenticeship with Messrs. Woodhouse and Rawson and with the Brush Electrical Engineering Company, after which he worked on the staff of Mr. S. Z. de Ferranti. In 1891, he acquired the telegraph instrument business of Messrs. M. Theiler and Sons and, in October, 1893, joined the firm of Messrs. Elliott Brothers, as partner, on their taking over the entire business of Messrs. Theiler. From 1916, when the original firm of Elliott Brothers was registered as a private limited company, Sir Keith acted as joint managing director, and, in January, 1934, he was elected chairman. In September, 1917, his efforts in connection with the design of fire-control equipment for the Admiralty were recognised by the award of the honour of Officer of the Order of the British Empire. March, 1920, he was made a K.B.E.

VARIABLE-SPEED ALTERNATING-CURRENT MOTOR.

MESSRS. HIGGS MOTORS, LIMITED, BIRMINGHAM.

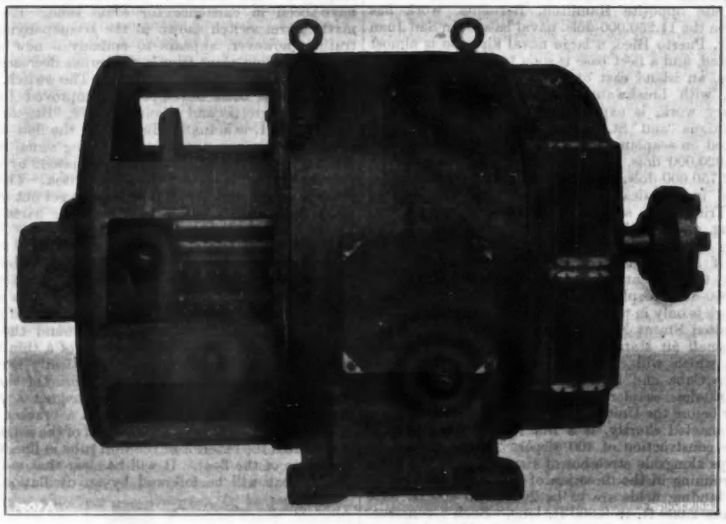


FIG. 1. 480-H.P. VARIABLE-SPEED COMMUTATOR MOTOR.

FIG. 2. TURNING COMMUTATOR OF VARIABLE-SPEED MOTOR.

ALTERNATING-CURRENT MOTORS.

WE have been informed that Messrs. Higgs Motors, Limited, Witton, Birmingham, 6, are now manufacturing large alternators and motors up to 600 h.p. In addition to alternators, the extended range includes polyphase variable-speed commutator motors, slip-ring induction motors, low starting current squirrel-cage motors, and auto-synchronous motors. In designing the range, due consideration has been given to the details of insulation and ventilation, in addition to those of the electrical and magnetic circuits.

Considerable attention has been paid to the provision of ample air ducts to sectionalise the stator and rotor cores and the provision of baffles where necessary, so as to direct an adequate supply of cooling air throughout all parts of the machine, and thus prevent the formation of hot localities in the centre of massive cores. It is claimed that the result is a machine, which is well balanced as regards temperature rise, efficiency, and overload capacity. Each machine is provided with two end brackets which carry the bearings, and the whole of the windings and interior are fully protected by the screening of all openings. Drip-proof and pipe-ventilated enclosures are also available. Other constructional details which may be mentioned include roller bearings at the driving end of the shaft, standardised and interchangeable terminal boxes with stud-type terminals, and fittings to accommodate the various types of cable which may be used.

The variable-speed commutator motor is an extension of the type which has been made in the smaller sizes for the past three years and, it is claimed, has proved satisfactory in service for various drives ranging from draw benches to laundry calenders, paper-making reelers and centrifugal casting tables. It consists essentially of an induction-motor stator with a wound rotor, the windings of which are brought out to a commutator. Speed variation is obtained by means of a separate induction regulator which produces a variable voltage without phase shift. The injection of this voltage into the rotor circuit of the motor gives the necessary speed variation with a shunt characteristic, so that the variation of speed with load, for a given regulator setting, is very small. Commutation is usually difficult in alternating-current motors and often limits the size of motor which can be manufactured, but in the Higgs machine this difficulty is eliminated by the employment of a special commutating winding on the armature, which, although connected to the commutator and therefore in parallel with the main armature winding, is arranged so that the corresponding coils of the main and commutating winding, which are connected together, do not have the same coil pitch and do not lie in the same slots. Briefly, the commutating winding provides a discharge path for the commutated energy and also serves to reduce the reactance of the coil undergoing commutation. Another point which may be mentioned is that no brush movement, with its consequent disturbance of brush bedding, is necessary. As a result, it is pointed out, brush wear is extremely small. Machines of this type can be made in any size up to 480 h.p. at 1,200 r.p.m., with speed ranges of 10 to 1, or higher in certain cases. A photograph of a 480-h.p. variable-speed commutator motor, with the commutator vent cover removed, is reproduced in Fig. 1, and Fig. 2 shows the rotor of this machine mounted in a lathe for turning the commutator. The speed variation is against a constant torque, so that the horse-power varies in proportion to the speed. With large speed variations, a self-contained fan would give insufficient cooling air at low speeds and would absorb too much power at high speeds. A small motor-driven blower is, therefore, incorporated which ensures an adequate supply of cooling air at all speeds. The construction of the induction regulator used in connection with these motors follows closely along the lines of the wound-rotor induction motor. Two units are mounted together vertically one above the other, and the base carries a small motor-driven fan, which blows cooling air through the windings and cores. It is claimed that this type of construction enables full use to be made of the active material, so that for a given output the weight of the induction regulator, and also the cost, is kept down.

Control of the regulator is by means of a handwheel and worm drive on to the regulator shaft. Alternatively, a small pilot motor geared down to rotate the worm shaft at a suitable speed may be employed. This enables complete automatic operation of the control to be obtained by a contactor panel. Cam-operated limit switches are fitted to prevent over travel of the regulator in either direction of rotation, and, in addition, further limit switches operated by adjustable cams can be used, so as to give pre-set speeds. These regulators are also used for supply-voltage regulation and will maintain a constant output voltage with varying input voltage either with hand regulation or automatically under the control of a voltage relay and a pilot motor on the regulator. The output voltage need not be the same as the input; for example, a group of 500-volt motors can be run off 400-volt mains by this means.

There are many occasions when a slip-ring motor is used merely to restrict the starting current and not necessarily to give a high starting torque. Large squirrel-cage motors, however, take a high starting current and do not give a very high starting torque, particularly if the efficiency at full load is to be maintained at a high value. It is claimed that the low starting current squirrel-cage motor mentioned above will give a starting torque much higher than an ordinary squirrel-cage machine, namely, 80 per cent. of full-load torque with about 1·8 times the full-load current. There are many occasions when this machine can be used in place of a slip-ring motor; for example, for driving fans, pumps, compressors, conveyors, etc. This starting torque is maintained throughout the accelerating period and the speed-torque curve has practically no dip in it. The machine embodies a standard stator of the usual construction, but the rotor has three rows of slots, of which the upper row contains a squirrel-cage winding consisting of bars brought out to two end rings in the usual manner. The slots in the second and third rows are alternate; a shallow slot in the second row is followed by a deep slot in the third row, then by a shallow slot, and so on. These slots contain bars which have been previously bent to the form of a "U." One side of a "U" piece is inserted in a shallow slot and the other side is introduced into a deep slot and the two free ends of this single-turn coil are then brazed on to a common end ring on one side of the rotor only. Thus, this lower winding, which is situated underneath the squirrel-cage winding, has a definite coil pitch. By the choice of a suitable coil pitch it is possible to eliminate any objectionable harmonics which would otherwise create a depression in the speed-torque curve, and any tendency to crawling is eliminated. It is claimed that the overload capacity of this type of rotor is considerably greater than is obtained with other forms of double squirrel-cage or high-resistance types of rotor and that, generally speaking, the power factor and efficiency are almost equal to those of an ordinary squirrel-cage motor, and, therefore, higher than for a corresponding slip-ring machine.

The makers state that the mechanical construction of the rotor is very robust and that the motors are suitable for duties involving heavy work and rough usage. At the same time the cost is less than that of a slip-ring motor and a further reduction in cost results from the simplified starting equipment. Machines can be made for direct starting if required, even in the large sizes. The starting current is approximately 3 to 3½ times the full-load current, or even less in favourable circumstances, and the starting torque is about twice the full-load torque. All the machines comply with British Standard Specification No. 168 and the manufacturing methods employed ensure interchangeability of similar parts and standardisation wherever possible.

ENGINEERING NOTES FROM THE UNITED STATES.

How rapidly the United States is developing the "arsenal of democracy" is indicated by statistics released early in June by the National Advisory Commission. The Commission's report shows that, in the ten months ended April 1, 1941, more than 1,600 factories and plants for defence or war purposes have been constructed or enlarged, or are nearing completion, at a cost of 2,839,503,000 dols. Many of these plants are already in use. Analysis of the statistics shows that plants for making aircraft or aircraft equipment account for 582,902,000 dols; those manufacturing tanks and other war vehicles total 50,121,000 dols.; factories to make guns and gun parts account for 182,550,000 dols.; plant for ship construction and ship-repair work will absorb 352,416,000 dols.; ammunition plants are shown as costing 591,960,000 dols.; and 1,079,558,000 dols. is being spent on various other types of plants, with no one classification outstanding. Figures compiled by the American Federal Government show that the National Exchequer is financing 2,000 million dollars of the total, or roughly three-fourths of the work described above; industry or private capital is financing the remainder. With the Government finance, 331 plants are being built, of which 99 will be owned by the Federal Government when completed. The remainder are to be privately owned, but operated for Federal Government purposes. Of the 99 Government-owned plants, 54, costing altogether 625,000,000 dols., will serve the War Department, and the other 45, totalling 400,000,000 dols., are for the Navy Department and its work.

The great extent of American defence or work for war purposes that can be expected in the United States in the fiscal year just beginning, *i.e.*, from July 1, 1941, to June 30, 1942, is well illustrated by the recent Congressional report, which showed that defence and non-defence appropriations already made total 33,311 million dollars for the fiscal year starting July 1, 1941. This total has never been approached before, being more than 14,000 million dollars over the previous highest. Of next year's Federal appropriations, some 15,500 million dollars is scheduled for defence or war purposes. This more than doubles the Congressional appropriations for war purposes during the year ended June 30, 1941, for which the Federal defence appropriations were 6,050 million dollars. The Office of Production Management, which is the Federal body set up to co-ordinate United States war efforts, has ordered an expansion of the steel production by ten million tons a year. The plan is to gain the additional capacity by expanding existing plants. The work is estimated to cost 1,000 million dollars or more, and is expected to require 4,160,000 tons of steel. The expenditure is to be met largely by loans from the National Government. Since the necessary construction will take about two years, the increased output is not expected to offset the 1,400,000-ton deficit predicted for the year 1941 for the United States and the 6,400,000-ton shortage anticipated for 1942. The above shortages are forecast by the Office of Production Management, which reports that the United States steel output for 1941 will be 91,339,000 tons, and will increase considerably in 1942. Exports to the British Empire are estimated at 8,500,000 tons during 1941 and 10,300,000 tons during 1942. It is interesting to note that in February of this year the same Federal organisation forecast a surplus of 10,100,000 tons in 1941 and 2,100,000 tons in 1942, but the increase of aid to Great Britain and defence activities at home have greatly changed conditions. Already in operation is a priorities system for certain constructional materials, including certain types of steel and steel products. Distribution is controlled by the Federal Government and the restrictions are on the increase.

American automobile manufacturers have been asked to reduce greatly their production because of the war effort; some reductions will be as great as 50 per cent. The request is made by the War Department in order to release men, materials and management for the production of aircraft, tanks, and other equipment for the United States, Great Britain, and the Allies. At least 20 per cent. of the output is to be effective by August 1, 1941, when the production of the new models for the coming year is scheduled to start. Greater reductions are expected later. The American automobile industry is the largest consumer in the country of strip and sheet steel. This is well illustrated by the fact that, in 1939, the industry used 49 per cent. of the country's strip-steel production and 44 per cent. of the steel sheet output. Figures are not available for last year's consumption, but the demand is estimated to be about the same.

In the twelve months since June 11, 1940, appropriations by Congress for the construction of air bases and Fleet shore facilities for the Navy Department in the Atlantic and Pacific oceans have totalled just over 1,000 million dollars. As the 12-month period ended, 750,000,000 dols. of the work had been placed under contract, which means that construction started almost immediately; work already completed amounts to 375,000,000 dols. A summary of the Atlantic base work shows that at Argentia, Newfoundland, work was started in January, 1941, on a 17,050,000-dols. development, to be completed by the coming winter. On a site opposite Hamilton, Bermuda, work has begun on the 11,250,000-dols. naval base. In San Juan harbour, Puerto Rico, a large naval air base is almost completed, and a fleet base is soon to be undertaken at Vieques, an island east of Puerto Rico. This undertaking, with breakwaters and other secondary but necessary work, is expected to cost 42,500,000 dols. On Antigua and St. Lucia islands, work is well advanced on seaplane operating stations, estimated to cost 2,920,000 dols. and 1,620,000 dols., respectively. The 2,750,000-dols. seaplane and ship anchorage planned in Jamaica is well begun. On the Gulf of Para, Trinidad, a seaplane base, fleet anchorage and berthing, and a limited amount of repair facilities and housing are planned at a cost of 17,855,000 dols.; but little, if any, of this construction is complete. In British Guiana, at a site on Essequibo River, a 1,800,000-dols. seaplane base is to be constructed, but this work is only in the preliminary stage. In addition, the United States Navy has selected a tentative site for a small air station, on an island of the Bahama group, which will command the Windward Passage between Cuba and Haiti. This work is to include a 2,555,000-dols. seaplane base.

Now before the United States Congress, and expected to be enacted shortly, is a Bill which would provide for the construction of 400 airport "flight strips" or runways alongside stretches of strategic military highways running in the direction of the prevailing winds. These landing fields are to be 200 ft. to 800 ft. wide and from 2,000 ft. to 8,000 ft. long. Such a construction is something entirely new in the United States, but is thought by the War Department to be highly desirable. Each "flight strip" is estimated to cost 50,000 dols. Details of the scheme have not been made known, but the programme is in addition to and separate from the large airport programme now under way throughout America.

Delivery of water from the Colorado River to nine Southern California cities, nearly 400 miles away, was begun on June 18 by means of the 392-mile long Colorado River Aqueduct, which was begun more than eight years ago, after 18 years of planning. The conduit cost 197,000,000 dols. and is to provide water for thirteen cities joined together as the Metropolitan Water District of Southern California. Delivery of water to the other four cities will be commenced soon.

ESSENTIAL WORK ORDER FOR ROAD HAULAGE.

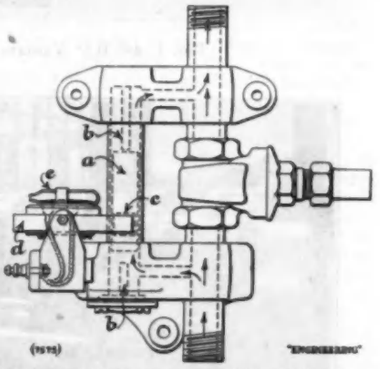
THE Minister of Labour and National Service has agreed to accept for scheduling under the Essential Work (General Provisions) Order, 1941, undertakings engaged in the road haulage industry which operate 20 or more vehicles. For this purpose he is prepared to regard undertakings as being within the industry if they operate vehicles under A or B licences, or if they operate vehicles under C licence alone, provided in the latter event that they can properly be regarded as engaged in road haulage and have a separate and identifiable department or staff engaged in this; scheduling in such cases would be confined to that department. The limit of 20 vehicles includes all goods vehicles in the undertaking, whether under A, B or C licences, and whether in one or more Regions. The Order provides that where an undertaking has been scheduled as engaged on essential work, the permission of a National Service Officer is required before an employee can leave his employment or before he can be discharged for any reason other than misconduct. It also lays certain obligations on employers regarding terms and conditions of employment. All undertakings desiring to be scheduled under the Order should make themselves fully conversant with the provisions of the Order, and study pamphlet EDL. 64, which may be obtained from any local office of the Ministry of Labour.

Any undertaking operating 20 or more vehicles that wishes to be scheduled should approach the appropriate Regional Transport Commissioner and request that its name should be submitted to the Minister of Labour and National Service. There is no special form of application, but any application should give the number of vehicles operated under A, B and C licences (or permits), respectively, the Regions in which these licences (or permits) have been issued, the number of employees engaged on road transport work, and a short statement of the work for which the vehicles are used. The scheduling of undertakings engaged in the road haulage industry and operating less than 20 vehicles is still under consideration, and a further notice will be issued in due course.

ALARM SWITCH FOR COOLING-WATER SYSTEMS

DEVICES for giving an audible warning or for stopping a machine when the temperature of the cooling water employed rises above a pre-determined maximum have been in existence for some time. The automatic alarm switch shown in the accompanying illustration, however, appears to embody a new method of safeguarding plant from a dangerous decrease in the amount of water being supplied. The switch, which has recently been developed in improved form by Messrs. Negretti and Zambra, 122, Regent-street, London, W.1, is actuated directly by the flow of water in the supply pipe, though the warning signal is transmitted, or a relay mechanism is actuated, by current passing through a tilting mercury switch. The apparatus is very simple and is not likely to get out of order, while there are no glands on the moving parts to give rise to friction or to cause leakage.

The body of the instrument consists of a valve of the gate type capable of precise adjustment by means of a movable key and situated on the inlet pipe of the cooling-water circuit, screwed connections on both sides of the valve being provided. A casting of roughly U-shaped outline forms a by-pass round the valve. The main leg of the by-pass consists of a thin tube in which a float *a* is free to move vertically through a distance determined by the stops *b b*. On the lower end of the float is a steel core *c*. A magnet *d*, carrying the mercury switch *e*, is pivoted on a bracket on the lower arm of the by-pass, and one end of the magnet projects across the exterior of the thin tube in line with the steel core of the float. It will be clear that movement of the float will be followed by an oscillation of the



pivoted magnet with consequent tilting of the mercury switch and making or breaking of the electrical circuit. The switch has a current-carrying capacity of two amperes at 250 volts. It is thus suitable for operating alarm bells, signal lights, automatic switchgear or relays, etc.

The gate valve is adjusted so that the area through it is less than the area of the pipe, and a pressure difference is, therefore, between the two sides of the valve. This difference results in a flow of water through the vertical tube, the float in which is not a tight fit. With the normal flow through the supply pipe, that is, the amount at which it is safe for the machine concerned to be operated, the float is held at the top of its stroke. With any reduction in flow below the safe limit, the float drops to the bottom of its stroke and the mercury switch is actuated. The float lifts when the head across the valve is approximately 8 in. water gauge and falls when this is reduced to about 6 in. An idea of the amount by which the valve must be closed for the desired operating conditions may be obtained from an example cited on a nomogram prepared by Messrs. Negretti and Zambra. In this the normal flow through a 2 in. pipe is 4,000 gallons per hour, and the switch has to operate when the flow has decreased to 80 per cent. of this, viz., 3,200 gallons per hour. The nomogram reading for this latter quantity is 0·87, which is the ratio of the diameter of the orifice to the diameter of the pipe. The valve must, therefore, be closed until the area through the orifice is equal to that provided by a hole 2 in. by 0·87, = 1·74 in. in diameter. The instrument cannot be damaged if the whole of the static pressure is applied either to the in-flow or out-flow sides. It is made suitable for a maximum pressure of 60 lb. per square inch.

INSTITUTION OF ENGINEERS, INDIA.—The year 1941 marks the coming of age of the Institution of Engineers, India. The Institution was founded in 1920 and was granted a Royal Charter in 1935 during the presidency of Sir Guthrie Russell, K.C.I.E.

LABOUR NOTES.

As last week's two days' House of Commons debate on Production was on the votes for the Ministry of Supply and the Ministry of Aircraft Production, only one or two of the speakers appeared to have anything new to say on the man-power problem. No doubt, when the vote for the Ministry of Labour and National Service comes up members with knowledge of the actual position will be less reticent. One of the most helpful contributions to the discussion on the second day was made by Sir Robert Young, who, it will be recalled, was, before he entered Parliament, general secretary of the old Amalgamated Society of Engineers. He is still one of the Amalgamated Engineering Union's Parliamentary representatives. He said that it would be very serious if anything were done to undermine the wage agreements between employers and workers. The object of everyone should be not so much to criticise the Government as to help it in the very difficult task of speeding up the production of war material more of which was still required. He trusted that employers guilty of mismanagement or of careless manufacture—of which he had heard cases—would be penalised, and he also trusted that workmen who did not accept the arrangements set down by the trade unions for settling difficulties would be told to toe the line or join one of the fighting Services.

On paper, Mr. Bevin's new organisation to "improve" the production of war material looks promising, for the men who are to some extent to comprise the Area Boards are apparently to be "practical" men. The official members are, however, to be local representatives of the Admiralty, Board of Trade, Ministry of Aircraft Production, Ministry of Labour and National Service, Ministry of Supply, the Emergency Repair Organisation of the Ministry of Works and Buildings, the Regional Transport Commissioner, the Raw Materials Department of the Ministry of Supply, and the chairman of the Machine Tool Area Committee. No reasonable exception can be taken to the composition of the Central Joint Advisory Committee, although one may sympathise with the members when they are called upon to "adjudicate" on decisions of bodies composed of so many local interests as the new Area Boards appear to be.

At its annual conference—which took place at Swansea last week—the National Union of Railwaymen approved by 60 votes to 19 the principle of the Essential Work Order. If such an Order is applied to the railway industry, the organisation will expect, it was stated, a guaranteed minimum wage of 3*l.* a week (excluding war bonus) and provision to preserve existing agreements relating to the negotiation of wages, hours and service conditions and pension rights. The delegate who moved the resolution, which was carried, said that railwaymen recognised that it was the Government's duty to organise the nation's man-power for the successful waging of the war. It savoured of the Fascist idea to say that a man getting a wage which did not meet his physical needs should be prevented from accepting other work for which he would receive better pay. That was why, he argued, a 3*l.* a week minimum wage, plus war bonus, should be a condition of the Order.

During the discussion, Mr. Marchbank, the general secretary of the organisation, pointed out that the railway companies had not asked for the Order. The trade unions had taken advantage of it in order to ensure that proper conditions and rates of wages were applied. He was not afraid of the Order, because it would give the members of the union advantages which they did not now possess. It would give them a guaranteed week's wage, and it would not only tie workers to the industry, but would also make provision for newcomers drafted into it. Moreover, it would guarantee shopmen a week's wage.

In the Essential Work Order covering the building industry, payment by results is stipulated for certain classes of work. The National Federation of Building Trades Operatives said in a statement issued last week:—"This Federation and its affiliated organisations have been and are still opposed to any diversion from the principle of plain-time wage payment, believing that any other form of wage payment can only lead to chaotic conditions and a consequent fall in production." The Federation admits that its opposition can now only be in principle as the introduction of the system is based on legislation. "We do not," it says, "expect our members to bring themselves into conflict with the law of the country, nor can we direct them to oppose actively this system where it may be introduced." But, it continues, "The building industry has for many years been basically a plain-time-rate industry, and attempts to alter this fundamentally sound tradition, even to meet the needs of war-time conditions, is bound to have the most serious repercussions."

It was suggested in a recent note that if all the present applications for increases of wages go to the National Arbitration Tribunal the question of labour costs as a whole—to use the wider term—was likely to become one from which the Government could not afford to stand aloof. Apparently, events are tending to support that forecast, for it is stated that, last week, the General Council of the Trades Union Congress considered representations on the subject made to it by the Chancellor of the Exchequer and the Minister of Labour and National Service. The British Employers' Confederation has also, it is understood, been consulted.

The Ministry of Labour and National Service states that the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed at June 16 was 121,562—a decrease of 20,422 compared with May 12. Of the total, 34,763 had been classified by interviewing panels as unsuitable for ordinary industrial employment. Those registered as on short time or otherwise temporarily suspended from work, on the understanding that they were shortly to return to their former employment, numbered 18,046; this was a decrease of 9,738 compared with May 12.

The corresponding figures for women and girls at June 16 were 122,094 wholly unemployed (of whom 3,975 had been classified by interviewing panels as unsuitable for normal full-time employment), 29,687 temporarily stopped and 747 unemployed casual workers. Between May 12 and June 16 the total numbers of men, boys, women and girls on the registers decreased by 14,846 in the London area, 3,834 in the Eastern area, 1,595 in the Southern area, 5,186 in the South Western area, 3,629 in the Midlands, 3,475 in the North Midlands, 374 in the North Eastern area, 8,865 in the North Western area, 7,119 in the Northern area, 9,274 in Scotland and 8,852 in Wales.

It has already been mentioned in these Notes that in the industries for which statistics are regularly compiled by the Ministry of Labour and National Service the changes in rates of wages reported to have come into operation in May resulted in an aggregate increase estimated at about 41,300*l.* in the weekly full-time wages of 470,000 workpeople and in a decrease estimated at about 300*l.* in those of 24,000 workpeople. Of the estimated total increase of 41,300*l.* a week, about 2,550*l.* was due to the operation of sliding scales based on fluctuations in selling prices or in the proceeds of the coal-mining industries, 10,300*l.* to arrangements made by joint standing bodies (including 2,100*l.* under cost-of-living sliding scales arranged by such bodies), 4,600*l.* to the operation of other sliding scales based on the cost of living, and 150*l.* to arbitration awards. The remaining 23,700*l.* was the result of direct negotiations between employers and workpeople or their representatives. The whole of the estimated decrease of 300*l.* a week was due to the operation of sliding scales based on the proceeds of the coal-mining industry.

The number of trade disputes involving stoppages of work reported to the Ministry of Labour and National Service as beginning in May was 113. In addition, 11 disputes which began before May were still in progress at the beginning of that month. The approximate number of workpeople involved in these 124 disputes (including workpeople thrown out of work at the establishments where the disputes occurred) was 23,000 and the aggregate duration of the disputes in May was about 74,000 working days.

During the five weeks which ended on May 31, 1941, the expenditure on unemployment allowances (excluding the cost of administration) amounted to approximately 536,000*l.* compared with 475,000*l.* during the four weeks which ended on April 26, 1941, and 1,452,000*l.* during four weeks which ended on May 25, 1940. Comparison of the figures for April and May, 1941, with those for the corresponding months of 1940 is affected by the increase, in November, 1940, in the scale which forms the basis for the calculation of unemployment allowances.

THE LATE MR. E. KILBURN SCOTT.—We have learned with regret of the death of Mr. Ernest Kilburn Scott, M.I.E.E., A.M.Inst.C.E., on July 12, at his home in Claremont-square, N.1. He was 73 years of age.

THE MEASUREMENT OF ROAD SURFACE ROUGHNESS.

IN the issue of ENGINEERING for June 19, 1936, vol. 141, page 660, a brief description was given of an apparatus for obtaining a graphical record for the irregularities of road surfaces. This apparatus was developed by the Road Research Laboratory and is carried on 16 articulated wheels which keep it at a constant average distance above the road surface. A pendant central single wheel running on that surface actuates a pen which traces a record of the contour on a moving chart. This apparatus is only one of the numerous types which have been developed in this country and elsewhere in the attempt to measure the surface roughness of roads, and, in order to give an idea of another manner in which the problem has been attacked, an apparatus at what might be called the opposite end of the scale, in that it has a single wheel only, is described below. The single-wheel apparatus has been developed by the Division of Tests, Public Roads Administration, U.S.A., and a full account of it is given in a paper by Messrs. J. A. Buchanan and A. L. Catudal, published in the February number of *Public Roads*, a journal issued by the Federal Works Agency, Public Roads Administration. A description of the apparatus based upon this paper is given below.

In an introductory review of the different methods for measuring surface roughness hitherto adopted, the paper mentions as reasons for not adopting the wheel suspension method, that the apparatus involved is awkward to manœuvre, the data obtained from it are difficult to analyse, and the desired comparisons tedious to make. The alternative method considered involves the recording of the spring deflection of a vehicle by means of apparatus embodied in the vehicle. The exact manner in which the apparatus functions is by no means uniform in the several types, but, generally, the result obtained is either a continuous graph of the vehicle spring deflection or a numerical integration of these movements in inches of deflection per mile of road surface length. The method of spring deflection with an integrating recorder was selected for investigation. Extensive tests showed that the results obtained when the integrating apparatus is part of the car were affected by the characteristics of the car employed—and it was decided to design an apparatus which could be towed by a car and standardised so that it could be readily reproduced. The new equipment is that referred to earlier as having one wheel only.

The design is very simple as will be seen from the diagrammatic drawing, Figs. 1 and 2, on page 58. A rectangular frame *a* of rolled-steel channel of standard section is spanned by a bridge *b* and has a Y-shaped tongue *c* at the front for attachment to a towing vehicle. The wheel is situated in the centre of the frame, its axle being attached to the centre of two single-leaf springs *d*, one on each side. The springs are connected to the end members of the frame, the connection being made as a pivot at the front and with a shackle at the rear. The frame is thus suspended on the springs but, in order to damp out undue oscillation on a rough surface two fluid dashpots *e* are inserted between the springs and the bridge. The bridge also carries the integrating mechanism *f*, this being connected to the wheel axle by a wire cable *g*. A balance weight is attached to the front end member in order to keep the centre of gravity in the plane of the axles. The total weight of the apparatus is 740 lb., of which 580 lb. is carried by the wheel and 160 lb. by the towing hitch. This hitch maintains the trailer with the wheel in a vertical plane but freedom of movement is ensured by a universal or gimbal joint suitable for attachment to most types of towing vehicle.

The wheel has a 16-in. by 6-in. four-ply balloon tyre with a plain ribbed periphery, this size having been chosen as a standard commercial product. The springs are made from silicon-manganese spring stock, 2½ in. wide by 0·344 in. thick. The deflection is approximately 100 lb. per inch. The axle is of heat-treated chrome-molybdenum steel and passes through the clamping blocks of the springs below the spring level. The wheel hubs are provided with adjustable roller bearings. The mountings at the points of attachment of the springs to the frame are fitted with standard grease-seal ball bearings. The dashpots are plain cylinders connected at the bottom to the spring blocks by ball thrust joints. The pistons are 3 in. in diameter and the rods are similarly connected to the bridge. Collapsible leather sleeves protect the rods against water and dirt. The piston has two holes, each ¼-in. diameter, through it, the oil in the cylinders flowing through the holes as the piston moves. The length of the ports has been determined by experiment and baffle plates with suitable orifices are fitted to prevent surging.

The integrating mechanism is shown in Fig. 3, page 58. As already stated, the principle of recording the roughness of the road surfaces by automatically

ascertaining the total of the deflections of the springs in inches per mile has been adopted. It follows, then, since the springs move both up and down, that one movement only must be transmitted to the recording point. The method of effecting this will be clear from Fig. 3, which is a simplified longitudinal section of the mechanism. It consists of a helically-grooved drum *a*, round which is wound two turns of the wire cable *b* on a mean circumference of 6 in. Inside the drum is a coiled clock spring *c*. The end of the cable remote from the drum is attached, by an adjustable connection, to the leaf spring block. When the axle moves downwards the cable is partially pulled off the drum against the spring torque, which is practically constant, and the drum is rotated. On the movement of the axle upwards the spring torque rotates the drum in the opposite direction. The selected movement, which is that of the axle moving downwards, is transmitted electrically to a counter. A commutator *d* has six equally-spaced contacts and a single brush *e*. One revolution of the commutator thus causes six closures of the electrical circuit which actuates the counter and, since the pitch circle of the drum *a*, that drives the commutator, is 6 in. in circumference, it follows that each impulse to the counter marks the accumulation of 1 in. in the vertical movement of the axle relative to the trailer frame.

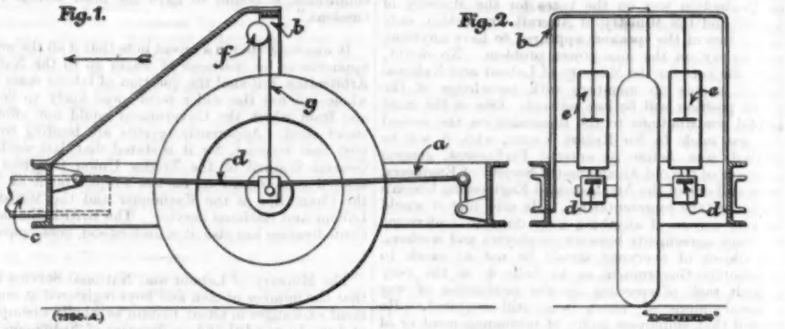
The connection between the drum and the commutator is interrupted by the two ball clutches *f* and *g*. The outer race in both clutches is a plain cylinder 1·4 in. in diameter, but the inner race has eight steps, at an angle of 15 deg., to provide wedging planes for eight spring-loaded steel balls, ¼ in. in diameter. When the axle moves downwards, the drum shaft rotat he outer race of the clutch *f*, and the balls of this clutch lock it to the inner race, which is mounted on the of the commutator. The whole rotating assembly then moves round and eventually the completion of the electrical circuit by the rotation of the commutator registers 1 in. on the counter. But, when the axle moves upwards and the rotation of the drum is reversed, the commutator is held fast by the balls of clutch *g*. the balls of clutch *f*, allowing freedom of the drum in this reverse direction of rotation. The instrument is completely sealed against dust and water, and the internal parts are lubricated during assembly and thereafter on completion of each 2,000 miles of trailer travel. Both the driving and driven shafts are mounted in ball bearings, the outer bearings in each case having seals on their outer faces. The electric impulses from the commutator are transmitted through a cable to an instrument board, which is designed so that the operator in the towing vehicle can hold it on his knee. On the board are mounted the counter recording the road roughness units; a counter recording wheel revolutions to provide a measure of the distance travelled; a switch controlling both counters; and a stop watch. There is also space for data sheets. The counters, which are of the magnetic type, operate on current at 6 volts and the storage battery of the towing vehicle provides a convenient source of power. The transmitting cable is weatherproof and is fitted with plug connectors. Protection of the system against overload is provided by a circuit breaker.

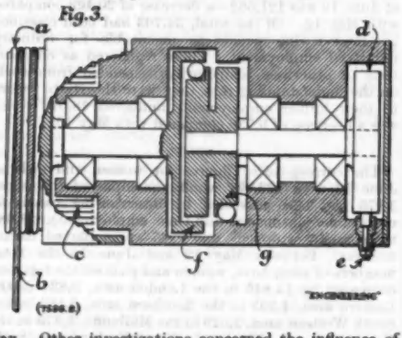
As the apparatus would be virtually useless if a high degree of consistency of performance were not secured, extensive investigations were made in connection with factors likely to influence the performance. Some of these investigations are referred to below. The behaviour of the spring-damping equipment received careful study. Since the trailer must be capable of operating under a wide range of temperature conditions, the damping liquid should not be liable to freeze and its viscosity should be affected as little as possible by changes in temperature, evaporation, or chemical changes such as oxidation; it should, moreover, be non-corrosive. The solution to the problem was found in a mixture of equal volumes of a light refrigeration oil and kerosene. The viscosity range over a temperature variation from 20 deg. F. to 120 deg. F. is about 100 seconds to 40 seconds, on the Saybolt universal viscosity scale. The tyre equipment was studied with equal care, the effect of tread design, tread wear and inflation pressure being considered. The first two of these factors turned out not to be of real importance, but the conclusions were reached that a plain-ribbed tyre should be replaced before the grooves entirely disappear due to wear, and a patched tyre or one that has become otherwise unbalanced should not be used. Inflation pressure, on the other hand, is a factor of major importance, and a pressure of 30 lb. per square inch, ± 0·5 lb., is recommended. A calibrated gauge of the Bourdon type should be used and not an ordinary commercial tyre pressure gauge.

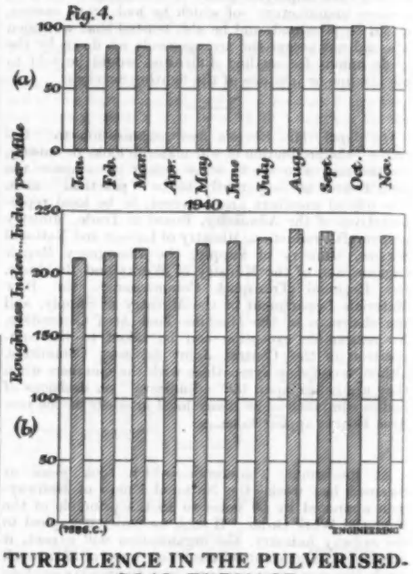
The influence of the speed at which the trailer is towed was found to be considerable and experience and accumulated data limit this to 20 m.p.h. A variation of 0·5 m.p.h. above or below 20 m.p.h. does not cause material changes in the roughness index, and the speed selected enables adequate testing of a considerable mileage of road surface to be done in a day. Other investigations concerned the influence of the type of towing vehicles, and tables are provided showing that there was no significant difference in the index of roughness obtained when a light passenger car, with a wheelbase of 109 in., and a ½-ton van, with a wheelbase of 113 in., were used. The consistency of the records obtained by making repeated runs over the same stretch of road was also investigated and found to be satisfactory. Since the same stretch of road may differ in roughness in the transverse direction tests were also made by taking parallel runs along the same stretch. The differences between one track and another, as might be expected, were very small and their detection bore witness to the sensitiveness of the apparatus.

It is not proposed to give any detailed account of the employment of the apparatus in practice, but one example of its utility may be cited. Since it is constant as regards performance, it enables periodic surveys of road conditions to be made, such surveys giving quantitative data regarding the difference in roughness caused by traffic, road bed changes, and so forth. The results of some such surveys are shown in Fig. 4. The graphs (*a*) in this figure are for a concrete surface built on a fill across a marsh, the road having required "mud-jacking" in the past. The graphs marked (*b*) are for a bituminous concrete surface. Both graphs represent monthly surveys for a period of 11 months. The roughness index is in inches per mile. The first series of graphs shows a fairly stable condition for the first five months of the period, after which the roughness increases progressively. The second series shows still more irregular conditions, and indicates that patching is required from time to time. It is considered that such records will be of value to those responsible for road construction and particularly to the staff responsible for road maintenance.

MEASUREMENT OF ROAD SURFACE ROUGHNESS.







FOREIGN-TRADE CONVENTION, NEW YORK.—The 28th National Foreign-Trade Convention, New York, will take place from October 6 to 8. Particulars may be obtained on application to the Secretary, National Foreign-Trade Council, Incorporated, 26, Beaver-street, New York, N.Y., U.S.A.

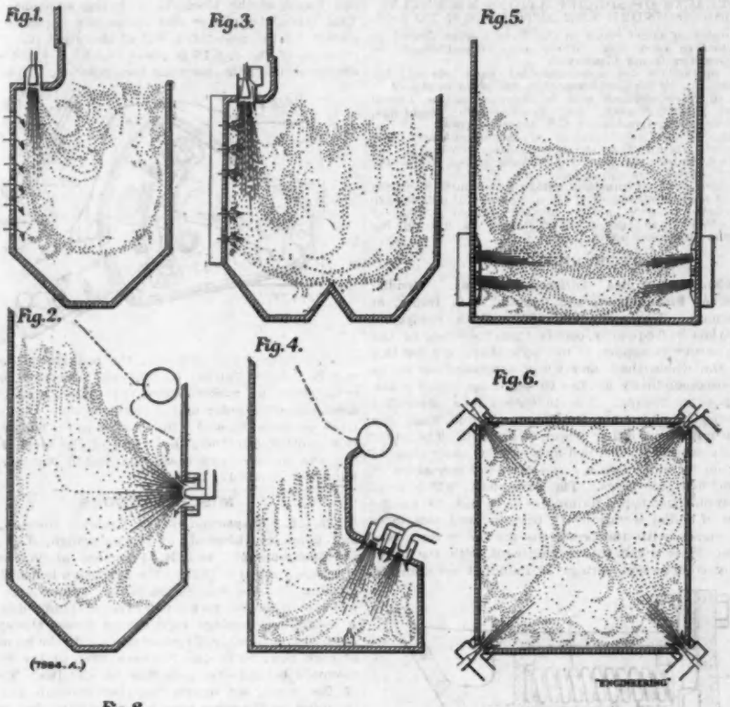
NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At the end of last year the North-East Coast Institution of Engineers and Shipbuilders completed a membership-affiliation agreement with the Society of Naval Architects and Marine Engineers, of New York. The members of the American Society who, under the agreement, have become connected with the Institution include the President, Rear-Admiral E. S. Land, chairman of the United States Maritime Commission, and Rear-Admirals H. F. Johnson and J. G. Tawresey, both of whom are members of the Council of the Society.

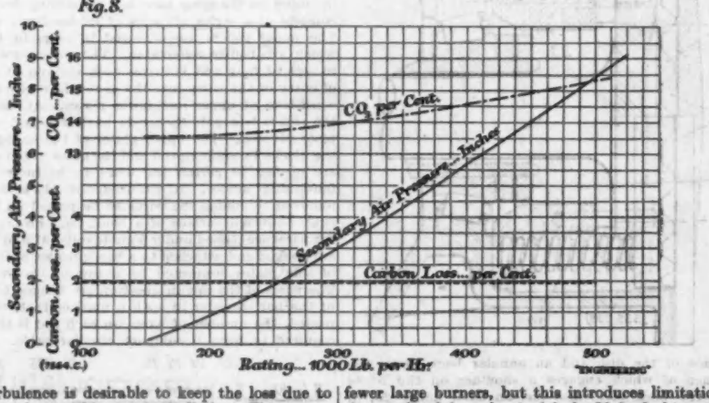
TURBULENCE IN THE PULVERISED-COAL FURNACE.

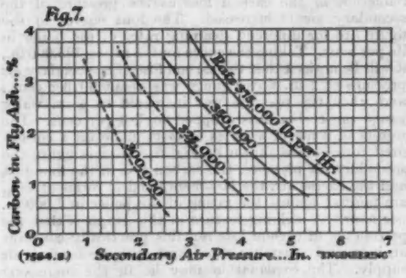
THERE is little doubt that in the early applications of pulverised coal to boiler firing the traditions regarding air supply appertaining to solid coal firing persisted for some time. As long as sufficient air was admitted, it did not seem to be realised that a high degree of turbulence was necessary to secure effective combustion of the finely-divided fuel. This necessity is now recognised as is clear from the amount of attention that has been given in recent years to the subject. A recent and informative contribution is made to it in a paper read by Mr. B. J. Cross, at a joint meeting of the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers, and entitled "Turbulence and Combustion in the Pulverised-Coal Furnace." This paper, reprinted in full in *Mechanical Engineering* for March, 1941, does not lend itself well to abridgment, but a short summary of it may be of interest.

In opening his subject, the author does not assert that turbulence in a pulverised coal furnace is unnecessary; some degree of it must always be present, but he examines its nature and limits in relation to combustion. In the earlier pulverised-fuel installations having furnaces lined with bare refractories, flames were kept away from the walls, secondary air was admitted at a low velocity and in such a way as to give what may be described as "gentle" burning, and combustion rates were kept low to avoid high furnace temperatures with consequent slag formation. The introduction of the furnace with complete water-walls removed these limitations and in such furnaces a high degree of turbulence is essential. The primary and secondary air supplies are given high velocities to ensure an active combustion zone in the vicinity of the burner, this resulting from the mixing of fuel and oxygen due to the inherent turbulence of the entering stream of air-borne fuel and from the entry of the secondary air. As combustion proceeds, the furnace atmosphere becomes depleted of its oxygen and is diluted with the products of combustion. The last of the carbon must, therefore, be burned in an atmosphere containing only some 2 per cent. to 3 per cent. of oxygen and con-

TURBULENCE IN PULVERISED-COAL FURNACES.







tinued turbulence is desirable to keep the loss due to unburned carbon within economic limits. This secondary turbulence is of a different nature from the primary turbulence.

The author gives a clear account of the differences between laminar and turbulent flow in a pipe or duct and concludes that, at the velocities occurring in furnaces, laminar flow cannot occur. He then goes on to discuss the different methods of firing pulverised-coal furnaces. Turbulence within a furnace results from the inherent turbulence of the jets, the impingement of the jets on each other, and the deflection and eddying due to the restriction of the jets by the furnace walls. The function of the primary air is to introduce the fuel in such a way as to ensure prompt and stable ignition and adequate distribution to all parts of the furnace. Its pressure is relatively high, ranging from 6 in. to 15 in. water gauge, according to the method of firing adopted. The secondary air is introduced into the furnace at or near the burners, in a manner designed to promote speedy mixing with the burning fuel of the primary air stream. It is supplied in larger quantity than the primary air and at a somewhat lower pressure, this last, in the main, from considerations of operating economy.

The early installations of pulverised coal operated with secondary air supplied under natural draught. A typical arrangement is shown in Fig. 1. The firing is in a vertical direction and a long flame-path is provided. The secondary air, induced by natural draught, enters at low velocity through ports distributed along the path of the flame. A number of small burners is more effective in producing turbulence than fewer large burners, but this introduces limitations in the supply of the pulverised fuel. If the fuel is prepared in a large mill and drawn from a storage bunker, a number of small burners is not difficult to provide for, but when the supply to the burner is direct from the mill, the lay-out is not a very practical one and the fewer burners per boiler the better. The next step was to use forced draught, a typical furnace of this kind being shown in Fig. 3. The secondary air is introduced in smaller high-velocity jets lying in a plane closer to the burner nozzles in order to break up the primary air streams quickly. The greater degree of turbulence resulting allows of higher combustion rates and the front and side walls of the furnace are, in consequence, generally water-cooled. While this system has been used with direct firing in both large and small units, the advantage of the storage system applies when a number of burners are used, furnaces of this type being often fired from two sides and as many as 20 burners have been used in a single unit. In completely water-cooled furnaces, combustion rates as high as any in modern practice have been obtained.

The horizontal firing arrangement shown in Fig. 2 was next developed. In this, the whole of the air used for combustion is introduced through the burner opening. The primary air streams are given a whirl within the burner nozzle, either by helically-disposed blades at the air entrance or by propeller-like spinners at its mouth, in order to distribute the coal across the furnace, and to provide a large conical surface to the jet for contact with the secondary air. A spin is also imparted to this air by controllable tangential vanes at the inlet to the burner throat. The amount and nature of the spin of the secondary air may be regulated so that this air does not strike the primary air stream forcibly until ignition is well established. The shape of the flame can also be controlled by the secondary air vanes. Horizontal turbulent burners are well adapted to direct firing, since they may be of large capacity, and, therefore, few in number. Usually two burners to four burners are used, although in small installations single burners have been successful. In storage-system installations as many as eight burners have been used. A type of burner used exclusively for slagging-bottom furnaces is shown in Fig. 4. The burners are usually set in an arch situated low down in the furnace front wall, or sometimes in the side walls, and are inclined downwards towards the furnace bottom. High velocities are employed for both primary air and secondary air, and both streams impinge on the furnace bottom. A high degree of turbulence is obtained, with the resultant high local temperatures necessary for slagging.

The different degrees of turbulence obtained with the burner arrangements in Figs. 1 to 4 are indicated approximately by a dotted disposition of the air streams, but although they vary considerably, the air streams are not, on the whole, much broken up. The arrangement illustrated in Figs. 5 and 6, which show the elevation and plan, respectively, of a corner-fired furnace, indicate, on the other hand, a high degree of turbulence. This results, in general, from the interaction of the primary and secondary jets directed from the four corners of the furnace. A minimum of four burners is clearly necessary, but two burners per corner give greater flexibility and three burners or four burners per corner have been used. The burners are usually directed so that their centre lines in plan are tangent to a circle of from 6 ft. to 8 ft. diameter. In recent installations the angle of the burners in plan can be adjusted while the furnace is in operation, so as to vary the diameter of this circle. The distance from the burner mouth to the tangent circle is short and the jets impinge on one another at a high velocity, setting up an eddying movement of a cyclonic character so that the furnace is completely filled with the burning mixture. The cyclonic effect persists, to some extent, to the furnace outlet and assists in completing the combustion of the carbon particles. These particles, being very dense compared with the gases, tend to move in straight lines, the gases themselves taking a generally helical path. The position of the particles relative to the gas stream is thus constantly changing. The corner-fired arrangement is applicable to both slagging-bottom and dry-bottom furnaces.

The latter part of the paper includes an attempt to assess quantitatively the value of furnace turbulence. Assuming that the burner design and arrangement is such that the energy of the primary and secondary air streams is usefully employed in producing turbulence, the degree of turbulence attained is measured by the velocity of these streams. The kinetic energy of the gases flowing out of the furnace is determined by its mass and velocity, or in a given furnace by the amount of fuel burned and the amount of air introduced with it. The difference between the kinetic energy of the entering streams and that of the gases leaving the furnace might be considered to be the equivalent of the turbulence produced. As the energy of the gas stream leaving the furnace is constant for a given combustion rate and excess air, the degree of turbulence created in the furnace is proportional to the energy of the streams entering it. The effectiveness of furnace turbulence may be measured by the amount of unburned carbon in the ash leaving the furnace, the so-called "fly ash." As the cost of supplying air to the furnace increases with the velocity imparted to it, there must be an economic limit to the pressures used. In this, the law of diminishing returns applies and the economic limit may be established empirically.

The results of some tests made on a furnace fired with horizontal burners are shown in Fig. 7. The percentage of combustible in the ash leaving the furnace is plotted against the pressure of the secondary air.

This pressure was regulated by the degree of opening of the burner vanes, and the amount of excess air was kept constant. It will be seen that there is a definite reduction in the carbon loss as the pressure of the secondary air is increased. The four curves in the figure are for different steaming rates of the boiler in lb. per hour. Taking the curve for the rating 325,000 lb., it will be noticed that the carbon loss at a secondary air pressure of 2 in. water gauge was about 30 per cent., and when the pressure was increased to 4 in. water gauge the carbon loss dropped to 7·5 per cent. The results of some of a series of tests made on a corner-fired furnace are shown in Fig. 8. In this figure the secondary air pressure, the carbon loss in the flue dust and the excess air, the last-mentioned in terms of CO_2, are plotted against the rating of the boiler in 1,000-lb. per hour. A striking feature in this graph is that the percentage of carbon loss remains practically constant at increased steaming rates and with decreasing air supply. The explanation may lie in the increasing secondary air pressure which increases the degree of furnace turbulence.

The graph, Fig. 8, is accompanied in the original paper by reproductions of graphs of variations in furnace draught. These were made by a sensitive instrument of the diaphragm type, the charts being rotated by a high-speed clock. The frequency of the variations is from 4 cycles to 6 cycles per second, and their amplitude increases with the boiler rating. Similar charts taken on tests made on other furnaces are also given, but it would appear that the author is not wholly satisfied that they possess any very great value at present; for one thing, the records may suffer from the inertia and natural period of vibration of the instruments. He is of opinion, however, that the pressure variations are associated with vibrations resulting from turbulence, and considers it possible that the method may be found to be a measure of relative furnace turbulence, at least when its technique has been further developed.

MOLYBDENUM IN IRON AND STEEL.

In the course of a paper presented some time ago before the Metropolitan Section of the American Society of Mechanical Engineers, Mr. T. D. Parker gave an account of the benefits to be derived from additions of molybdenum to iron and steel. He stated that when the metal was added to iron castings which were to be subjected to elevated temperatures, it retarded the rate of structural changes, thereby tending to equalise stresses caused by uneven temperatures and gave improved strength and toughness at both room and elevated temperatures. Furthermore, molybdenum helped in the dispersion of the carbides and refined both the grain structure and the distribution of the graphite. Chromium or vanadium were usually added in conjunction with the molybdenum for high-temperature applications, to give added carbide stability, thereby reducing growth during subsequent service. Among the molybdenum steels, the comparatively low-cost chromium-molybdenum material was widely used in the aircraft industry, on account of its weldability in light sections and high strength-weight ratio. Nickel-molybdenum steels were also well known on account of their ability successfully to withstand distortion during carburising and oil-hardening treatments. The low-carbon types of this steel were extensively employed for carburised parts in cases in which a hard, tough, and wear-resistant surface was desired.

One of the most important applications of molybdenum was in connection with steels to resist high temperatures. Additions of the order of 0·40 per cent. to 0·60 per cent. of molybdenum resulted in a pronounced increase in the creep strength of a steel. For operating temperatures of up to 1,000 deg. F. (540 deg. C.), molybdenum might be the main alloying element present in the steel. For higher temperatures, chromium, or chromium together with an increased proportion of silicon, were introduced with the molybdenum to give the material the necessary additional corrosion and oxidation resistance. In some of these steels the molybdenum content was raised from the customary 0·40 per cent. to 0·60 per cent. range to as much as 1·50 per cent. to give added resistance to creep and to reduce temper brittleness. Molybdenum-bearing tool steels had been introduced as early as 1904, but further attention had been paid to them in recent years. One type of molybdenum high-speed steel contained, in addition to carbon and vanadium, from 4·0 per cent. to 6·5 per cent. of molybdenum and an equal amount of tungsten. This was somewhat subject to decarburisation during fabrication and heat treatment, but the addition of 2·5 per cent. of copper practically eliminated any remaining tendency of the steel to decarburise. With these molybdenum alloys, industry had available, at a lower cost, high-speed steels suitable for practically any cutting application which, in the past, had been met by steels of the tungsten and tungsten-cobalt types.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

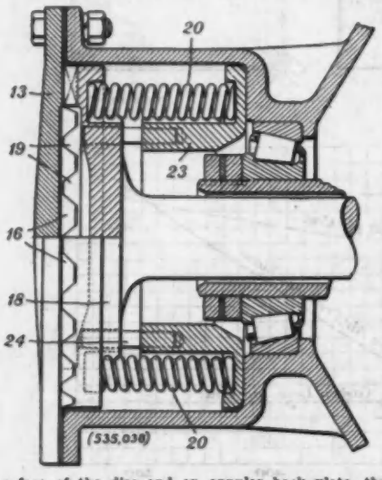
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

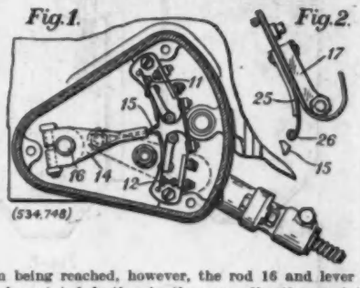
MOTOR VEHICLES.

535,038. Controlled Differential Gear. Bendix, Limited, of Birmingham, and Captain J. S. Irving, of Birmingham. November 20, 1939.—With controlled differentials it frequently occurs that the whole of the driving torque is applied to one axle shaft, and for this reason the whole shaft and wheel assembly has to be made correspondingly heavier to stand up to the maximum possible torque. The invention is a controlled differential in which the maximum torque that can be transmitted to either wheel is limited. The outer end of the wheel hub is closed by a circular cover plate 13 having on its inner face a series of radial serrations 16 with inclined side faces. The axle shaft, which is of the fully-floating type, terminates in a disc 18 having a series of radial serrations 19 with inclined side faces which engage with the serrations on the cover plate. The disc 18 is urged into engagement with the cover plate by compression springs 20 mounted between the



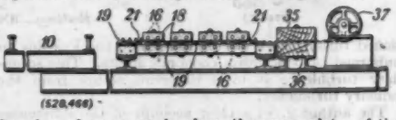
rear face of the disc and an annular back plate, the rear face of which engages a shoulder on the wheel hub. The back plate also has an axial flange 23, in which are secured studs 24 projecting forwards into openings in the disc 18, so that the two parts rotate together. Provision for adjustment is made by shims between the cover plate 13 and the flange to which it is bolted. Under normal conditions the shaft and hub rotate as a unit, the drive being transmitted through the serrations on the cover plate and the disc, which are held in engagement by the springs 20. When, however, an excessive torque is applied, the serrations ride over one another, and in so doing they give an audible warning to the driver. Relative movement between the shaft and the wheel hub is also resisted by the friction between the back plate and the shoulder on the hub, and this resistance can be increased by forming the engaging surfaces of these parts as parts of a cone clutch. (*Accepted March* 26, 1941.)

534,748. Switch for Preselector Gearbox. Legonda Motors, Limited, of Staines, and C. W. Sewell, of Staines. (*5 Figs.*) October 21, 1939.—The switch is designed for use with a gear change arrangement, synchronism being effected electrically. Such a switch is required to close temporarily when the switch lever is moved in one direction but to remain inoperative when it is moved in the other direction. Switches 11, 12 for third and second speeds, respectively, and in another plane a third switch for first speed alongside the switch 12, are operated by a single lever 14. This lever carries a V-ended insulating block 15 and is secured to the end of a rod 16. Each switch includes a rocker 17 (Fig. 2) carrying the movable contact and a curved guide 25, and between the guide and the rocker is secured a spring blade terminating in an eye 26, which lies in the path of the V-end of the insulating block 15. Rotation of the lever 14 by the rod 16 in one direction engages the V-end of the block 15 with the adjacent eye 26. This turns the rocker and closes the contacts in the circuit for the associated coil of the gearbox. Further rotation of the rod 16 is prevented by a synchro-mesh device until synchronism has been reached. On synchro-



nism being reached, however, the rod 16 and lever 14 can be rotated further in the same direction past the eye, when the rocker opens the switch contacts and de-energises the coil; and at the same time, the synchro-mesh device is engaged. On rotation of the rod and lever in the other direction, the V-end of the block 15 pulls the eye so as to maintain the switch contacts open. (*Accepted March* 17, 1941.)

MISCELLANEOUS.

528,466. Suspension-Bridge Cables. Dorman, Long and Company, Limited, of Middlesbrough, J. F. Pain, of Middlesbrough, and R. Freeman, of Westminster. (15 *Figs.*) April 8, 1939.—The invention is a method of forming *in situ* suspension-bridge supporting cables, which each consist of a number of parallel individual wires. A continuous haulage rope carries across the span, in succession, a number of rows of wires. In the preparation of each row, coils, one for each wire in the row, are mounted behind one anchorage on spindles. The ends of the wires are drawn together through guides 10 mounted on the same base as a tensioning device which consists of a series of pairs of rubber-faced rollers 16. The upper rollers are arranged in pairs in blocks 18, which are bodily removable. The rollers are arranged in sets of four and between each set and at the point of entry of the wires into the device is a wire spacer 19, consisting of upper and lower plates. At each end of the rollers is a gate spacer 21 having a part of the top plate pivoted. The upper plates of the spacers 19 and the blocks 18 are removed and the gates of the spacers 21 are opened to permit the wires to be inserted in the tensioning device. A rubber-faced block 35 is also removed to enable the wires to be placed on the upper rubber-covered surface of a block 36. From the latter the wires are passed under a guide roller 37 and their ends are hooked and attached to a bar-spreader which consists of side plates connected by a row of transverse rods. The wires of the row in question are hooked to each rod of the bar spreader in such a manner that, when compacted, the number of wires on each rod is the number required to form a compact circular cable. When all

the wires of a row are in place, the upper plates of the spacers 19 and the blocks 18 and 35 are replaced and the upper rollers 16 are clamped down on the wires. The bar-spreader is then drawn away from the tensioning device for, say, 30 ft., the ribbon formation of the wires being maintained by the use of further loose spacers. The wires between the bar-spreader and the adjacent loose spacer are then compacted into a circular group by a clamp. When the wires have been compacted, the compacted part is bound by soft-iron wire and secured in a socket. The socket is then drawn across the span by the haulage rope. While the ribbon is being drawn across the span, spacers are attached at intervals to maintain the alignment of the wires. The pressure exerted on the wires by the rollers 16 as the ribbon is drawn across, is varied to keep the sag approximately constant. A pilot wire previously placed across the span at the level of the ribbon facilitates the control of the roller pressure. When the ribbon reaches the anchorage at the far side of the span, it is passed over the anchorage strut and the socket is secured to an anchorage rod. The various ribbons are finally arranged on the saddle on the tower. After the end of a ribbon has been fixed to its anchorage, the sag is finally adjusted and the end of the ribbon between the coil and the tensioning device is then compacted, cut and fixed in a socket and, after removal from the tensioning device, is finally connected to its anchorage. (*Accepted October* 30, 1940.)